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## The larvae of European Myrmeleontidae (Neuroptera)

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## Abstract

The larvae of the European Myrmeleontidae are reviewed with the aim to ease their identification, covering 15 genera and 28 species. Diagnostic characters and illustrations are given for each taxon. Larvae of the genera *Nemoleon* and *Macrone-murus* are described for the first time while *Megistopus*, *Neuroleon* and *Myrmeleon* are revised. The larvae of *Dendroleon pantherinus* (Fabricius), *Macrone-murus appendiculatus* (Latreille), *Megistopus lucasi* (Navás), *Nemoleon notatus* (Rambur), *Neuroleon arenarius* (Navás), *Neuroleon assimilis* (Navás), *Neuroleon nemausiensis* (Borkhausen), *Cueta lineosa* (Rambur) and *Myrmeleon gerlindae* (Hölzel) are described or accurately depicted for the first time.

**Key words:** Myrmeleontiformia, antlions, larval morphology, identification, Mediterranean, Western Palaearctic

## Introduction

The order Neuroptera, as currently established, is mostly based on larval characters (U. Aspöck 1992; U. Aspöck *et al.* 2001) and even the reciprocal relationships between families are mainly elucidated by the study of larval morphology, as underlined for the first time by the unmatched work of Withycombe (1925) and confirmed by recent studies (Beutel *et al.* 2010; Winterton *et al.* 2010). Myrmeleontidae are one of the larger families of the order, rivaling with Chrysopidae in the number of described species, comprising conspicuous insects and representing a major component of the insect fauna in arid environments, although at the same time representing a poorly known family whose systematics remains unclear (Mansell 1999).

The study of larval morphology is necessary to solve the complex systematics of Myrmeleontidae (Stange & Miller 1990; Stange 1994, 2004), presently mostly based on adult characters (Markl 1954). Despite the larvae of some species attracted the attention of the ancient naturalists thanks to their remarkable pit building behavior, earning the vernacular name “antlion” attested for the first time during the Middle Ages (Druce 1923; Kevan 1992), they are known only for a limited minority of species thus representing a serious obstacle to a better knowledge of the family. The European species of Myrmeleontidae are illustrative of the difficulties involving the study of the larvae of this family. The first accurate morphological studies on the European antlion larvae were undertaken by Brauer (1854, 1855a, 1855b, 1867), who understood for the first time the importance of the preimaginal stages in the systematics of Neuroptera, and Hagen (1873). Later works regarding the European fauna mostly deal with the descriptions of single species, such as the morphological studies of Principi (1943, 1947) and noticeably few original comprehensive and comparative works for identification purposes have been published (Redtenbacher 1884; Steffan 1968, 1975; Friheden 1973; Willmann 1977). Nevertheless, most of the European antlion larvae remain insufficiently known and frequently the existing description are not deepened or simply based on occasional findings. At the same time the ecology of numerous species remains unknown.

The present study is the result of a three years field research mainly conducted in southern Europe, especially in the western Mediterranean, with aim to improve the state of knowledge of the larvae of Myrmeleontidae of the genera present in this area. This work culminates a series of studies on this subject realized by the authors (Cesaroni *et al.* 2010; Pantaleoni *et al.* 2010; Pantaleoni & Badano 2012).

## Material and methods

The larvae were directly collected in the field or alternatively obtained from eggs laid by adult females. In the first case, they were directly located at sight for the pit building species or by sieving the substratum. The oviposition was obtained by keeping the females in containers partly filled with sand, superiorly closed with paper or a net and with some sticks as support; if the condition are optimal the female lays the eggs into sand. The two methods, the direct research of the larvae in the field and rearing from eggs, provide complementary information: ecological requirements of each species and sure identification respectively. Afterwards, the larvae were reared in the laboratory in order to check the identification or to obtain the 3<sup>rd</sup> instar, being the first two instars not suitable for diagnostic purposes. Rearing was carried out in a dedicated room with a mean temperature of 25°C and 60% humidity while during winter the larvae were moved into an unconditioned room to simulate natural conditions. The antlions were kept in small cylindrical plastic containers a third filled with sand; for some species with different substratum preferences, loose soil or vegetal detritus were used instead. The preys were constituted by

yellow mealworm larvae, *Tenebrio molitor* Linnaeus (Coleoptera: Tenebrionidae) and by cockroaches (Blattodea: Blaberidae gen. sp.) of adequate size. Newly hatched larvae were fed with bean aphids, *Aphis fabae* Scopoli (Hemiptera: Aphididae). After spinning the cocoon, the specimens were placed in larger and higher containers provided with a stick to allow the eclosion of the adult.

Morphological observations were mainly conducted by means of a Leica® MZ9.5 stereomicroscope while measurements and photographs were taken using a Leica® MZ16 stereomicroscope equipped with a Leica® DFC320 digital camera. The photographs were elaborated using LAS (Leica® Application Suite) applied software Version 2.5.0 R1. Finally, the obtained images were processed and retouched using the software Adobe Photoshop® CS5 Extended Version 12.0.

The specimens were measured following the protocol applied by Cesaroni *et al.* (2010): the body length of larvae (BL) was measured from the head (excluding mandibles) to the tip of abdomen; the length of the head capsule (HL) was measured ventrally from the clypeo-labrum to the head insertion with the thorax, the head width (HW) was taken just below the ocular tubercles, at the point of maximum width; the length of the mandibles (ML) was measured from the apex to the base. In order to underline the respective proportions of the head and of the mouthparts, the ratio head capsule width/head capsule length (HW/HL) and mandible length/head capsule length (ML/HL) were calculated.

The number of interdental mandibular setae is reported for each species as a formula: (a)(b)(c)(d), where a = number of setae in the gap between mandible base and basal tooth; b = number of setae in the gap between basal and median teeth; c = number of setae in the gap between median and apical teeth; d = number of setae in the gap between apical teeth and apex of the mandible.

The larva instars are sometimes indicated as L1 (1<sup>st</sup> instar); L2 (2<sup>nd</sup> instar); L3 (3<sup>rd</sup> instar).

The larvae were preserved in 95° ethanol and deposited in the collections of the authors.

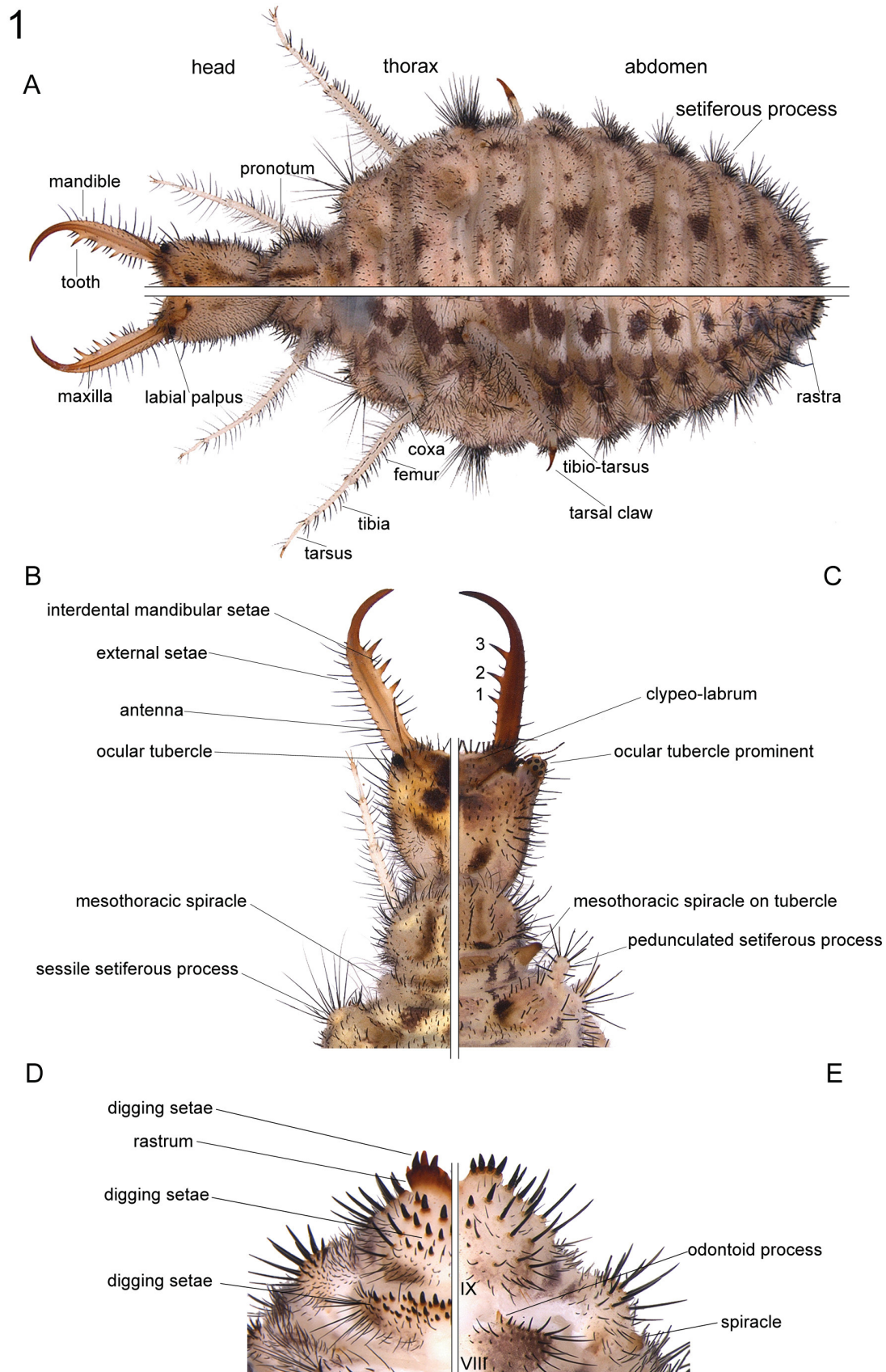
## Larval morphology

(Fig. 1)

**Chaetotaxy.** The larvae of Myrmeleontidae are equipped with a considerable diversified array of setae, often useful for identification purposes. Lipovšek Delakorda *et al.* (2009) recognized and termed four different types of setae: bristles, plumose hairs, dolichasters and digging setae. Dolichasters are an apomorphic character of Myrmeleontiformia and they can be disposed on all the tagmata, including mouthparts, and typically on the setiferous processes. However in Myrmeleontidae bristles and hairs are predominant, often giving to the larvae a hairy appearance.

**Body protuberances.** The thorax and abdomen of myrmeleontid larvae are covered by a considerable number of bunches of setae borne by protuberances/projections disposed on the lateral sides of the body (see below). Their prominence, shape, setae-thickness and disposition are very important for taxonomic and identification purposes, besides often offering a clue on larval habits. These protuberances/projections are clearly homologous in all Myrmeleontidae and the use of a general name is recommended despite the shape differences. So the term setiferous processes is adopted here. The very elongated and prominent setiferous processes (often named scoli) are defined here as pedunculated; when they are still recognizable as protruding structures but comparably shorter and stouter, they are termed sub-pedunculated. At last, sessile if they are not-pedunculated, bearing a thick tuft-like bunch of setae.

**Head.** The head is heavily sclerotized and sub-rectangular in shape. The profile of the clypeo-labrum is often a valuable diagnostic feature. The dorsal tentorial pits are very evident in most taxa, they are oblique and convergent from the base of the antennae toward the middle of the head. The anterior portion of the head is separated from the epicranial area by a pair of oblique frontal sutures converging in a median straight epicranial one suture running on the dorsal side of the head from the middle toward the posterior part of the head. The occipital foramen is dorsally placed, consequently the head is able to rise up and to withdraw with ease. The antennae are dorso-laterally disposed between the jaws and the ocular tubercle, borne by a slight protrusion; they are small and filiform, composed by a short scapus, a comparatively long pedicel and a slender flagellum. Each ocular tubercles brings 7 stemmata (6 dorsal and 1 ventral), whose size, position and prominence have diagnostic value. The labium is sclerotized, placed in the ventral-anterior portion of the head and encased by the lateral sclerites of the head capsule



**FIGURE 1.** Taxonomic characters of larvae of Myrmeleontidae. A, *Euroleon nostras* dorsal and ventral views; B, head of *Myrmeleon inconspicuus*; C, head of *Macronemurus appendiculatus*; D, IX and VIII sternite of *Myrmecaelurus trigrammus*; E, IX and VIII sternite of *Creoleon lugdunensis*.



The basal portion of the palpi, inserted on the mentum, is very distinct being large and characteristically swollen. This structure is controversial and it has considered the basal article of the palpi (Friedhede 1973; Principi 1943, 1947; Nicoli Aldini 2007) or a prelabial lobe (MacLeod 1964). Depending on the chosen option the number of palpomeres loses or gains a unit. In this paper the basal article is considered as an integral part of the labial palpus, so it is normally 4-segmented, rarely 3-segmented (in *M. bore*). The distal palpomere bears a sensorial pit. The gula is present and recognizable in the posterior portion of the labium and prosecuting as a straight line running all along the ventral portion of the head, often reaching its posterior margin. The small ventral tentorial pits are disposed along the side of the labium. The jaws are composed by very large, sclerotized and dorsally disposed mandibles and narrow, ventrally-placed maxillae (the respective cardo and stipes are visible ventrally); both elements are elongated, forming sucking tubes by mean of the median furrow. Jaws represent a very important diagnostic feature: their relative dimensions, shape and thickness, the disposition and dimension of their teeth allow to discriminate numerous taxa. In most species (including all the European ones) the teeth are 3 in number. The chaetotaxy of the mandibles has a great diagnostic importance: number, type and thickness of the setae disposed between the mandibular teeth, on the margins and on the surface. The internal margin of the mandibles is equipped with numerous setae disposed between the teeth. In some taxa a part of them is modified and transformed in “pseudo-teeth”; it should keep in mind that the “true” characteristic teeth derived from setae-bearing jaws processes (Stange, 1970). The ventral and dorsal surface of the jaws is often covered by short setae and in some taxa by dolichasters. The external margin of the mandible is normally equipped with setae, longer toward the base. In pit-building antlions, the setae of the external margin of the mandible are very long, creating a sort of basket useful to throw grain of sands.

**Thorax.** The prothorax is narrower and smaller than the other two thoracic segments, which are in turn not separated from the abdomen. An anterior subsegment is overall visible in lateral view. The following and main subsegment bears the first pair of legs and its tergite is the large and sclerotized pronotum. The disposition of the setae on its dorsal surface can be useful for identification purpose. Meso- and metathorax are broader than the prothorax while only the anterior mesothoracic subsegment, bearing the only pair of thoracic spiracles, has similar width. The sclerification, shape and prominence of thoracic spiracles are often discriminating features. Both meso- and metanotum are equipped with a pair of setiferous processes on each side, they are in sub-anterior position in the case of mesonotum, definitely lateral in metanotum. The anterior pair of mesothoracic setiferous processes is the most developed and prominent in many taxa. The sub-pedunculated setiferous processes can be more or less flattened or cylindrical. The metathorax is very short on the dorsal side but wide and well developed ventrally, therefore it is dorsally partly covered by the first abdominal tergite.

**Legs.** The leg pairs are characterized by a similar conformation and there are not considerable differences between the prothoracic and mesothoracic pairs except the larger dimensions of the latter. They are characterized by a large and robust coxa and a not segmented tarsus. The metathoracic pair of legs is notable for the fusion of the tibia and the tarsus and the enlarged tarsal claws (only one exception is known, see Stange 1994). The tibio-tarsal fusion is a character that Myrmeleontidae share exclusively with Ascalaphidae. In the antlion tribe Myrmeleontini the metathoracic legs are stouter than the other pairs and subject to a torsion, conditioning the whole movement of the larva, a modification probably due to their pit-building habits (see Myrmeleontini). In strong burrowers and especially in pit-building species, the mesothoracic and, more prominently, the metathoracic pairs of legs are equipped with a fringe of setae to move into the sand.

**Abdomen.** The abdomen is not visually separated from the thorax. It is composed by 10 segments but only the first nine are normally visible. The X segment is, in fact, telescopic and retracted inside the IX and VIII segments; it is specialized to spin the silk secreted by the Malpighian tubules during the construction of the cocoon. The tergites are not always recognizable due to the soft and elastic pleural area with which they gradually merge, while the sternites are normally discernible. Each of the first eight segments is equipped with a pair of lateral spiracles. The first pair of abdominal spiracles is normally migrated dorsally. Two series of setiferous processes are disposed dorsally and ventrally in respect to the abdominal spiracles. Each urite holds a supra- and an infra-spiracular process. In the I urite they are often reduced, vestigial or absent, in the VIII urite they can be fused together or reduced or absent. The VIII and especially the IX sternites are ventrally equipped with modified macrochetae used by the larvae to anchor themselves or to dig in the substratum according to their habits. Moreover, the VIII sternite is normally equipped along its posterior margin with a pair of tooth-like structures, termed odontoid processes. In some genera, specialized digging setae are also present on its surface. The IX

segment is conical, longer than wide in some genera. Nevertheless in most exponents of Myrmeleontidae this segment is short and wider than long for digging purposes. The IX sternite is equipped at its posterior margin with a pair of enlarged, sclerotized bulges each bearing 4 short and robust macrochetae, the digging setae; these structures are termed here rastra, singular rastrum (from the Latin rastrum, rastri-, rake). In some cases, other digging setae are disposed on the ventral side of the IX sternite in a more proximal position. In the tribe Palparini, the rastra, normally present in the first instar larvae, after the second moult turn in two very large, heavily sclerotized, triangular digging structures named fossoria. As a result of this conspicuous modifications the IX sternite, and in some case even the VIII, represents one of the most important features for identification purposes, especially in Myrmeleontini.

## Larval development and life cycle

Myrmeleontidae, as the other families of Neuroptera, have three larval stages. The life cycle is relatively constant among the studied European species and it is possible to delineate some common development traits. The adult female carefully chooses the oviposition site according to the specific ecological requirements; the type of substrate and its physical properties, such as density and particle size often play an important role in this respect (Matsura *et al.* 2005; Devetak *et al.* 2012). The first instar larvae hatch after 20–30 days, according to the temperature. The duration of each larval stage mostly depends from food availability and temperature; antlion larvae mostly live in arid environments thus they are well adapted to food paucity and they are able to survive relatively long period of starvation. The larvae stop feeding just before moult. The overwintering stage is always represented by the larva, however the overwintering larval instar is variable even in the same species as development depends on food availability. In late spring or summer the third instar larvae spin a spherical cocoon in which they pupate. Pupation lasts at least 20–30 days according to the temperature. In southern Europe, as it is clearly indicated by field samplings and observations, almost all species are both univoltine and semivoltine, despite the development of species characterized by large body sizes can last longer.

## Larval stages recognition

The most obvious difference between the larval stages of a same species is represented by dimensions, differing only in slight morphological characters. The 1<sup>st</sup> instar larva is often characterized by a comparable narrower head capsule with different relative proportions with jaws, moreover the setation covering the body is comparatively sparser. The colour pattern and especially the extension of dark markings can be very different between larval stages: first instar larvae of many species are immediately recognizable due to the darker head capsule, as the dark markings are more extended than in later instars (this does not occur in species with a pale colouring). 2<sup>nd</sup> and 3<sup>rd</sup> instar larvae are even more similar between them, with the exception of dimension.

Genus-level characters are generally distinguishable in all larval instars (see key 1). A notable (and only) exception is represented by the first instar of *Palpares*, lacking fossoria. Species recognition in first instar larvae can be very difficult instead, especially in some genera of Nemoleontini and in some *Myrmeleon*. Highly unmistakable species, such as: *D. pantherinus*, *Megistopus* spp., *G. variegata*, *A. occitanica* and *S. baetica*, are recognizable at a glance since the first instar.

## Key to the European larvae of Myrmeleontidae

- |   |  |                   |
|---|--|-------------------|
| 1 | IX abdominal sternite of 2 <sup>nd</sup> and 3 <sup>rd</sup> instar with fossoria (Fig. 2A, 7) . . . . .   | <i>Palpares</i>   |
| - | IX abdominal sternite without fossoria (Figs. 2, 3, 6). . . . .  | 2                 |
| 2 | Mesothorax with a median tuft of hair-like setae; IX sternite conical, longer than wide; mesothoracic spiracle not raised on tubercle (Figs. 3A, 8). . . . . | <i>Dendroleon</i> |
| - | Mesothorax without a median tuft of setae; IX sternite wider than long (Figs. 3B–H) . . . . .  | 3                 |
| 3 | Mesothorax with pedunculated or sub-peduncolated setiferous processes (Fig. 1C) . . . . .  | 10                |
| - | Mesothorax with sessile setiferous processes only (Fig. 1B) . . . . .  | 4                 |
| 4 | External margin of the mandible with a fringe of long setae reaching the apical tooth; basal setae longer than the width of the                              |                   |

|    |   |                          |
|----|---|--------------------------|
|    | mandible (Fig. 1B) .....  | 5                        |
| -  | External margin of the mandible with a small basal group of setae, not reaching the apical tooth and shorter than the width of the mandible (Fig. 25) .....   | 9                        |
| 5  | The median tooth is the largest, IX sternite with prominent rastra (Figs. 2B–D, 21) .....   | 6                        |
| -  | The apical tooth is the largest, IX sternite without prominent rastra (Figs. 6, 26) .....   | 8                        |
| 6  | Median and apical mandibular teeth directly in contact, without setae between them (Fig. 21) .....  | <i>Myrmecaelurus</i>     |
| -  | Median and apical mandibular teeth spaced by 1–2 setae (Fig. 22) .....  | 7                        |
| 7  | IX sternite thickly covered with small digging setae, also disposed on the ventral surface of rastra. ....  |                          |
|    | ..... <i>Nohoveus</i> (from Ábrahám & Papp 1990; Gepp 2010; Krivokhatsky 2011 and verified on non-European species)   |                          |
| -  | IX sternite covered with few very large digging setae, 1 large digging seta at the base of each rastrum (Figs. 2C–D). ....  |                          |
|    | ..... <i>Cueta</i> (key 5)  |                          |
| 8  | Presence (exclusive or not) of spiniform or stout setae on the posterior margin of the VIII abdominal sternite (Figs. 6A–H). . .  |                          |
|    | <i>Myrmeleon</i> (key 6)  |                          |
| -  | Posterior margin of the VIII abdominal sternite exclusively covered by hair-like setae (Fig. 6I) .....  | <i>Euroleon</i>          |
| 9  | Anterior margin of the labrum with a pronounced rounded lobe; mandibles swollen at the base; VIII sternite covered with digging setae (Fig. 24) .....   | <i>Acanthaclisis</i>     |
| -  | Anterior margin of the labrum without a lobe; mandible not swollen; VIII sternite without digging setae (Fig. 25) . . .   | <i>Synclisis</i>         |
| 10 | VIII abdominal sternite with prominent odontoid processes (Figs. 3B–F). ....  | 11                       |
| -  | VIII abdominal sternite without or with very reduced odontoid processes (Figs. 3G–H) .....  | 15                       |
| 11 | Dorsal surface of the head and pronotum covered by white scale-like setae (Figs. 4B, 9). ....   | <i>Nemoleon</i>          |
| -  | Dorsal surface of the head and pronotum covered by dark bristle-like setae (Figs. 4C–H) .....   | 12                       |
| 12 | IX sternite with an anterior group of ventral digging setae; mandibles very robust; basal and median teeth closer to each other than to the distal tooth (Figs. 3D, 10) .....   | <i>Creoleon</i>          |
| -  | IX sternite without an anterior group of ventral digging setae, mandibles comparatively slender, teeth equidistant (Figs. 3E–F). ....   | 13                       |
| 13 | Pronotum with 4 dorsal parallel series of large setae (Figs. 4F, 11) .....  | <i>Macronemurus</i>      |
| -  | Pronotum without distinct dorsal parallel series of setae (Figs. 4C, E) .....   | 14                       |
| 14 | Pronotum covered by long setae interspersed by short spiniform ones; rastra of IX sternite with digging setae of similar size (Figs. 3C, 4C, 12) .....  | <i>Distoleon</i> (key 2) |
| -  | Pronotum covered by long setae interspersed by dolichasters; rastra of IX sternite with inner digging seta long a half of the longest pair (Figs. 3E, 4E) .....   | <i>Neuroleon</i> (key 3) |
| 15 | Distance between the base of the mandible and the basal tooth longer than that between the basal and apical teeth; median and apical teeth equal sized; rastra of IX sternite with inner digging seta long a half the others (Figs. 3H, 20) .....                   | <i>Gymnocnemia</i>       |
| -  | Distance between the base of the mandible and the basal tooth shorter than that between the basal and apical teeth; apical tooth larger than the median tooth; rastra of IX sternite with inner digging seta long less than a third the others (Figs. 4G, 18). .... |                          |
|    | ..... <i>Megistopus</i> (key 4)   |                          |

## Tribe Palparini Navás, 1912

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule with protruding ocular tubercles; mandibles armed with three to five teeth; labial palpi four articulated, at least as long as the basal width of the mandible. Thorax with pedunculated setiferous processes; abdomen with sessile setiferous processes. VIII abdominal sternite equipped with large odontoid processes; IX abdominal sternite wider than long, characterized by the presence of fossoria.

**Remarks.** Fossoria are an exclusive character of later larval stages while 1<sup>st</sup> instar larvae are equipped with short rastra bearing four pairs of digging setae.

**Biological notes.** Large ambush hunter predators able to move both forward and backward.

**Comments.** This tribe is exclusively distributed in the Old World and it is particularly diverse in the Afrotropical region, where most of species are located. The larvae of very few species are known and even less of them are adequately described, making difficult to compare the larval characters of tribe. The fossoria are the main apomorphic characters.

## *Palpares* Rambur, 1842

**Diagnosis.** Mandibles strong, equipped with at least 3 pairs of teeth; mesothoracic spiracles borne on a very short tubercle; thoracic setiferous processes prominent, first pair of mesothoracic setiferous processes provided with a forward directed tuft of setae; VIII abdominal sternite with large odontoid processes; IX abdominal sternite with fossoria (2<sup>nd</sup> and 3<sup>rd</sup> instars only).



**Examined species.** *P. libelluloides* (Linnaeus, 1764).

**Comments.** The genus *Palpares* is considered polyphyletic (Mansell 1992, 2004) thus the above mentioned diagnosis is exclusively based on the type species: *P. libelluloides*, that is also the only member of the genus whose larva is sufficiently described (Brauer 1854). According to the present definition, *Palpares* comprises over 67 species widely distributed in the Old World, across the Afrotropical (the main center of distribution), Palearctic and Oriental regions.



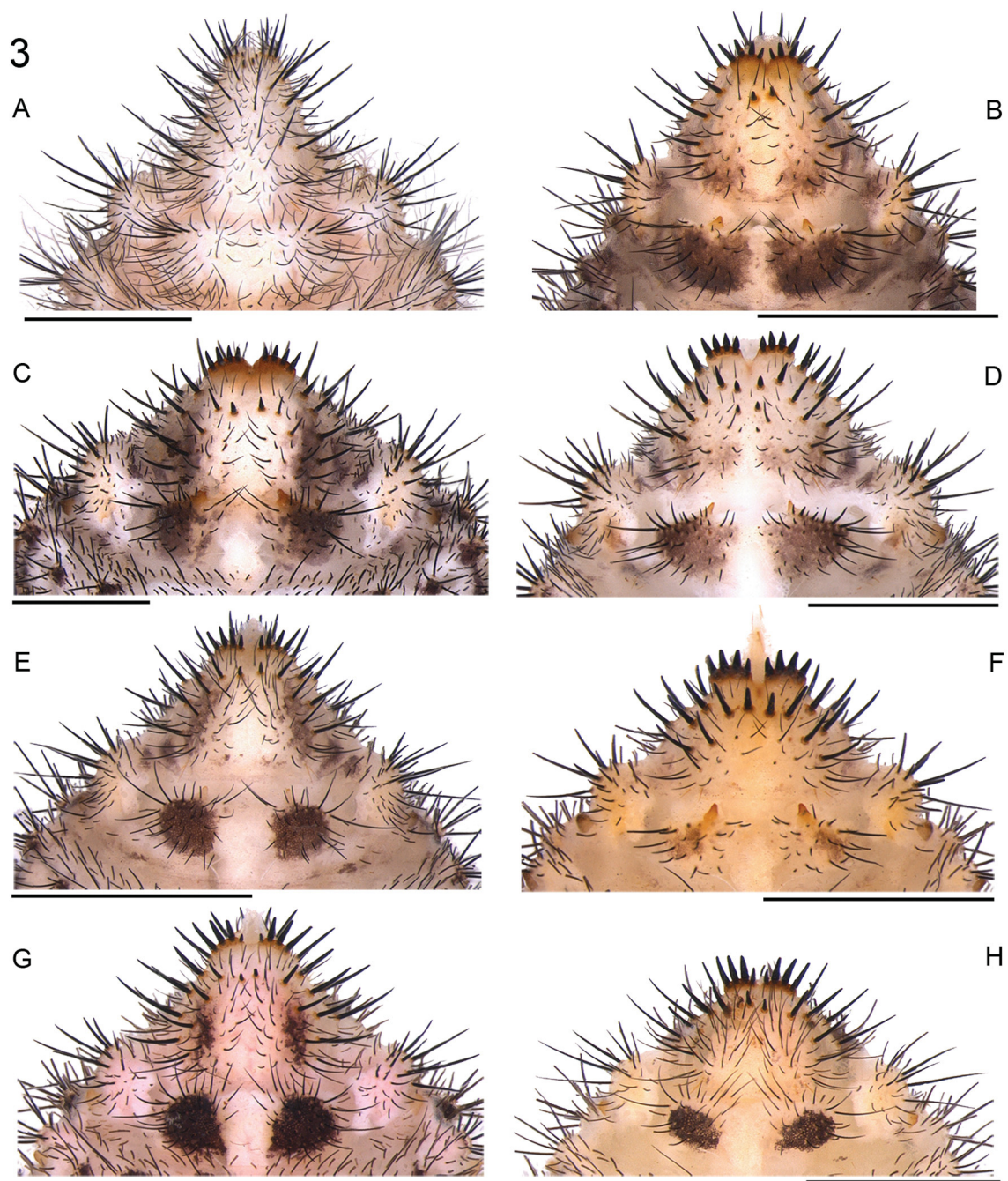
**FIGURE 2.** IX and VIII abdominal sternite of 3<sup>rd</sup> instar larvae of Palparini, Myrmecaelurini, Nesoleontini and Acanthacisini. A, *Palpares libelluloides*; B, *Myrmecaelurus trigrammus*; C, *Cueta beieri*; D, *Cueta lineosa*; E, *Acanthacis occitanica*; F, *Synclisis baetica*. Scale bar: 1 mm.

### ***Palpares libelluloides* (Linnaeus, 1764)**

(Figs. 2A, 7)

Despite the wide distribution and striking appearance of this species, the original descriptions and reports of its larva are surprisingly rare. The larva was described and illustrated for the first time by Brauer (1854) and later by Hagen (1873) and Redtenbacher (1884). Following descriptions are mostly based on these older accounts (Steffan 1975; Gepp & Hölzel 1989; Gepp 2010; Krivokhatsky 2011). In the past, the larva of this species was often confused with the equally unmistakable larvae of Acanthacisini simply for their large dimensions (e.g. Navás 1923).





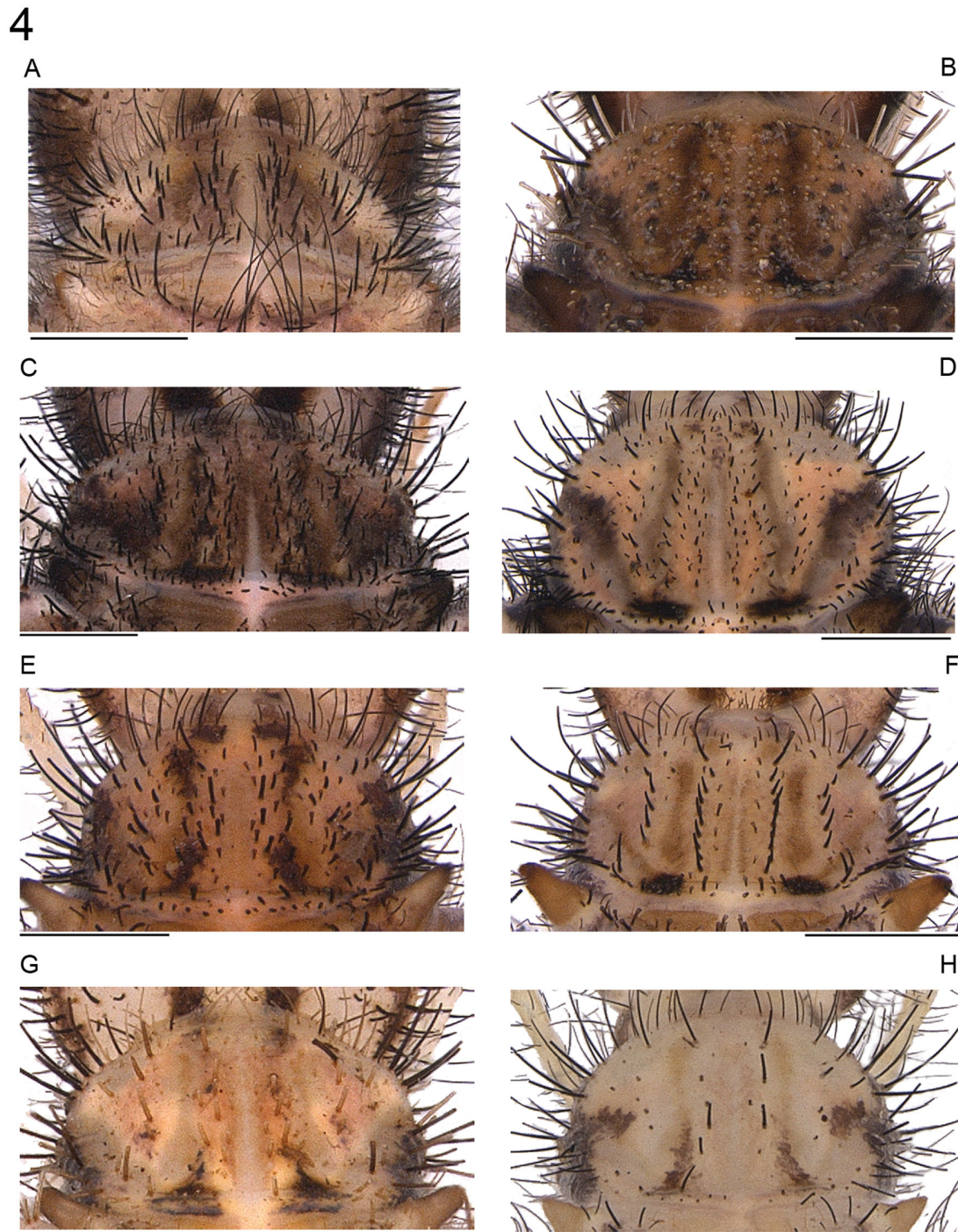
**FIGURE 3.** IX and VIII abdominal sternite of 3<sup>rd</sup> instar larva of Dendroleontini and Nemoleontini. A, *Dendroleon pantherinus*; B, *Nemoleon notatus*; C, *Distoleon tetragrammicus*; D, *Creoleon lugdunensis*; E, *Neuroleon assimilis*; F, *Macronemurus appendiculatus*; G, *Megistopus lucasi*; H, *Gymnocnemia variegata*. Scale bar: 1 mm.

**Examined specimens. France.** Aniane 44, Les Bernayves, IX.1985 (J. M. Males), 2 L3 (coll. B. Michel). **Italy.** Liguria, Genova, terrapieni or. (= oriental banks), V.1908 (G. Mantero), 1 L3 (coll. Museo civico di Storia naturale "G. Doria"). Liguria, 5 L1 laboratory-reared from a female collected at Cipressa (Imperia), scrubland, VII.2010 (D. Badano). Liguria, Perinaldo (Imperia), olive grove soil, VI.2011 (D. Badano), 1 L1 laboratory-reared to L2. Abruzzo, Cerchio (L'Aquila), Le Coste, III.1994 (Stornelli & G. Osella), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 4 specimens): BL 21.89 mm; HL 5.50 mm (5.15–5.85), HW 5.46 mm (5.36–5.57), ML 5.54 mm (5.33–5.95), HW/HL 0.99, ML/HL 1.01. General colouring brown with not contrasting darker markings, ventral side very pale, whitish; head capsule brown, lateral sides with large markings, ventral side of the head pale brown with dark margins, isolated brown spots are disposed at the insertion of bristles (Fig. 7h); mandibles black; legs pale; setae of the body black. Head quadrate, as long as wide, with large ocular

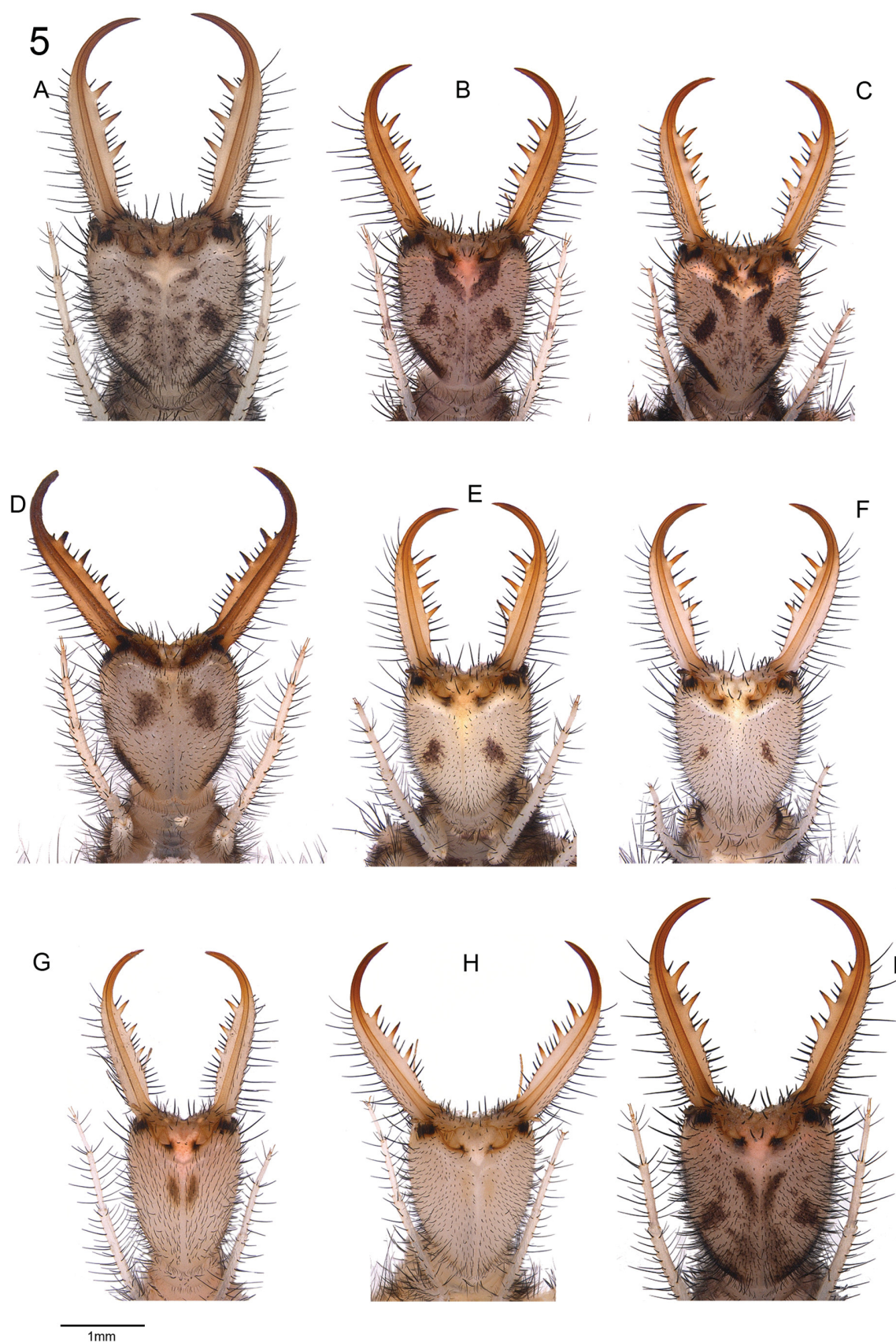


tubercles (Fig. 7c); margin of the labrum with a pronounced median incision (Fig. 7b); dorsal surface with a ridge starting at the very deep tentorial pit and ending laterally with a pair of tubercles (Fig. 7i); mandibles robust, as long as the head capsule; median tooth larger than the other teeth, median and apical mandibular teeth closer than the median and basal teeth (Fig. 7a); interdental mandibular setae extremely short: (~5)(3–4)(0)(0); a series of stout setae is distributed on the external margin of the mandibles; head surface covered by pale dolichasters. Pronotum with 4 dorsal parallel series of stout setae; mesothoracic spiracles pale on a short tubercle, surrounded by black hairs; first pair of thoracic setiferous processes (Fig. 7e) with forward directed tuft of black setae at its base (Fig. 7d). Abdominal spiracles large and dark. VIII abdominal sternite with large odontoid processes (Fig. 7g); IX sternite with fossoria (Fig. 7f).



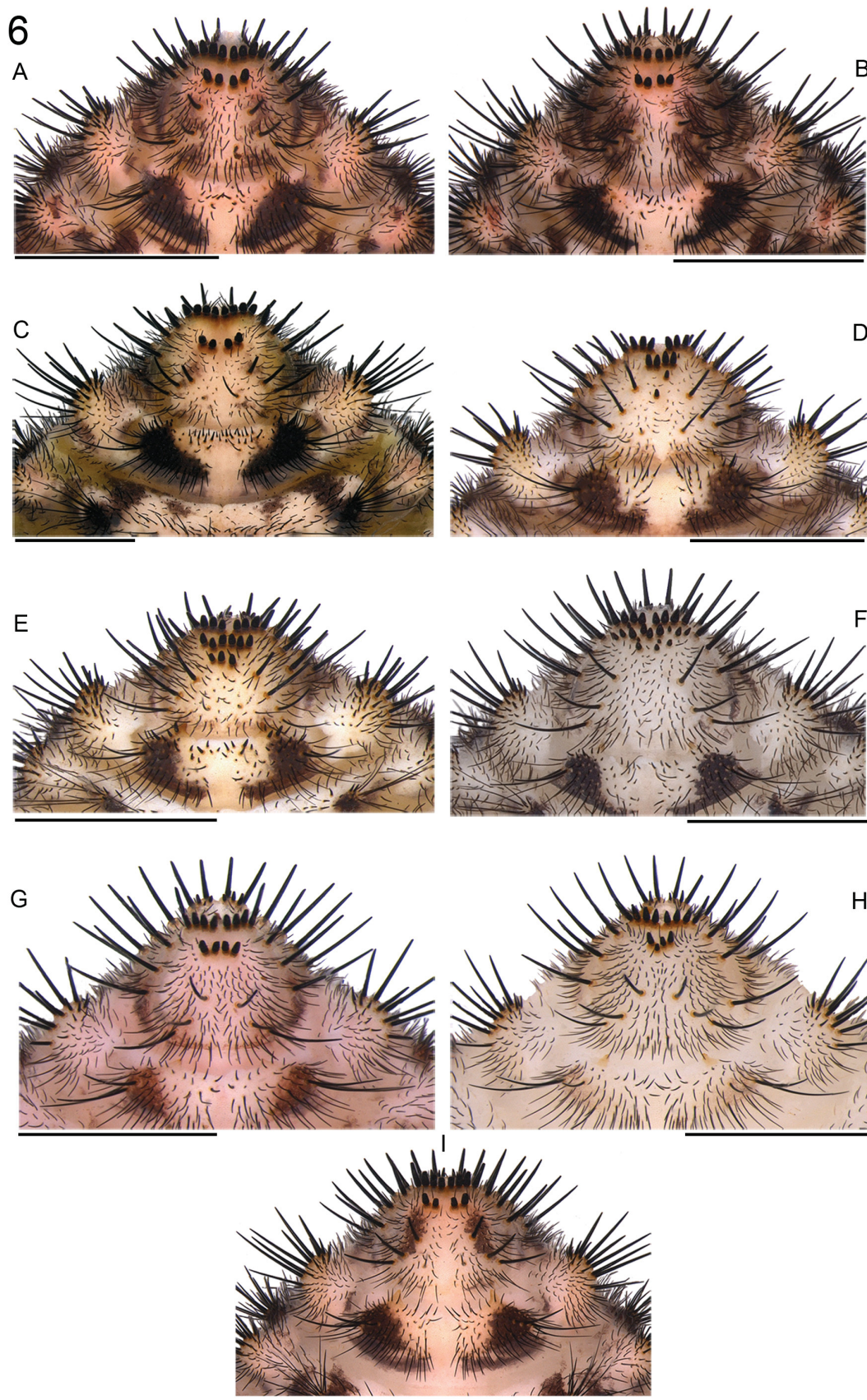
**FIGURE 4.** Pronotum of 3<sup>rd</sup> instar larvae of Dendroleontini and Nemoleontini; A, *Dendroleon pantherinus*; B, *Nemoleon notatus*; C, *Distoleon tetragrammicus*; D, *Creoleon lugdunensis*; E, *Neuroleon nemausiensis*; F, *Macronemurus appendiculatus*; G, *Megistopus lucasi*; H, *Gymnocnemia variegata*. Scale bar: 1 mm.





**FIGURE 5.** Head of 3<sup>rd</sup> instar larvae of Myrmeleontini, ventral view; A, *Myrmeleon formicarius*; B, *Myrmeleon gerlindae*; C, *Myrmeleon punicanus*; D, *Myrmeleon bore*; E, *Myrmeleon inconspicuus*; F, *Myrmeleon mariaemathildae*; G, *Myrmeleon hyalinus*; H, *Myrmeleon fasciatus*; I, *Euroleon nostras*.





**FIGURE 6.** IX abdominal sternite of 3<sup>rd</sup> instar larvae of Myrmeleontini, ventral view; A, *Myrmeleon gerlindae*; B, *Myrmeleon punicanus*; C, *Myrmeleon formicarius*; D, *Myrmeleon bore*; E, *Myrmeleon inconspicuus*; F, *Myrmeleon mariaemathildae*; G, *Myrmeleon hyalinus*; H, *Myrmeleon fasciatus*; I, *Euroleon nostras*. Scale bar: 1 mm.





**FIGURE 7.** *Palpares libelluloides* (Linnaeus, 1764), 3<sup>rd</sup> instar larva (France: Hérault, Aniane). Dorsal (above), ventral (middle) and lateral (below) view; a–i: diagnostic characters, see species description.

**Bio-ecology.** *P. libelluloides* is associated with open and warm but not excessively arid environments such as grasslands, scrublands, meadows and glades. The larvae live in soil of the biotopes frequented by the adults, buried into vegetal debris and gravel among roots and stones. This species appear to prefer a coarse substratum and it is normally absent from sites with the presence of fine sand, such as coastal dunes.

**Distribution.** Widespread species in the western Palaearctic.

**Remarks.** The 1<sup>st</sup> instar larva of *Palpares* shows remarkable differences from the later stages: the odontoid processes of the VIII sternite are noticeably smaller and the IX sternite is equipped with rastra bearing 4 digging setae. Nevertheless, the 1<sup>st</sup> instar larva of *Palpares* is equally unmistakable from other antlions due to the combination of prominent ocular tubercles, the median mandibular tooth largest and presence of thoracic pedunculated setiferous processes. In the Iberian Peninsula *P. libelluloides* is sympatric with the only other European congener, *P. hispanus* Hagen, 1860; the larva of the latter is not adequately known and the old existing descriptions are unconfirmed or misidentifications (Hagen 1873; McLachlan 1873).

### Tribe Dendroleontini Banks, 1899

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule with small ocular tubercles; mandibles bent upward in most genera; apical tooth longer than the other teeth; labial palpi four-articulated, segments 2–4 longer than the basal width of the mandible. Mesothoracic spiracles not raised on tubercle. Most genera are characterized by the presence of a median tuft of setae on the mesonotum. Thoracic setiferous processes pedunculated; abdominal series of setiferous processes sessile in most genera. VIII abdominal sternite without odontoid processes; IX abdominal sternite longer than wide, without rastra or fossoria.

**Biological notes.** The larvae are ambush hunters able to move both forward and backward.

**Comments.** The larvae of Dendroleontini are poorly known and only few genera are sufficiently described. The members of this group often present peculiar specializations and extra-European taxa differ in the number of mandibular teeth, presence of mesothoracic tuft of setae and development of abdominal setiferous processes.

### *Dendroleon* Brauer, 1866

**Diagnosis.** Anterior margin of the clypeo-labrum slightly concave; mandibles bent upward, equipped with 3 equidistant pairs of teeth; ocular tubercles prominent but small; mesonotum with median tuft of black hair-like setae raising in proximity at the base and re-approaching at the apex; mesothoracic and abdominal spiracles not prominent; thoracic setiferous processes pedunculated; VIII abdominal sternite without odontoid processes; IX abdominal sternite noticeably longer than wide, without rastra or fossoria.

**Examined species.** *D. pantherinus* (Fabricius, 1787).

**Comments.** *Dendroleon* is a widely distributed genus, present in North America, Eurasia and Australia, comprising about 20 species (Stange 2004). The larvae are known only for *D. pantherinus*, the N-American *D. obsoletus* (Say, 1839) and *D. speciosus* Banks, 1905 and finally the Taiwanese *D. esbenpeterseni* Miller & Stange, 2000 (Stange *et al.* 2003; Stange 2004, 2008).

### *Dendroleon pantherinus* (Fabricius, 1787)

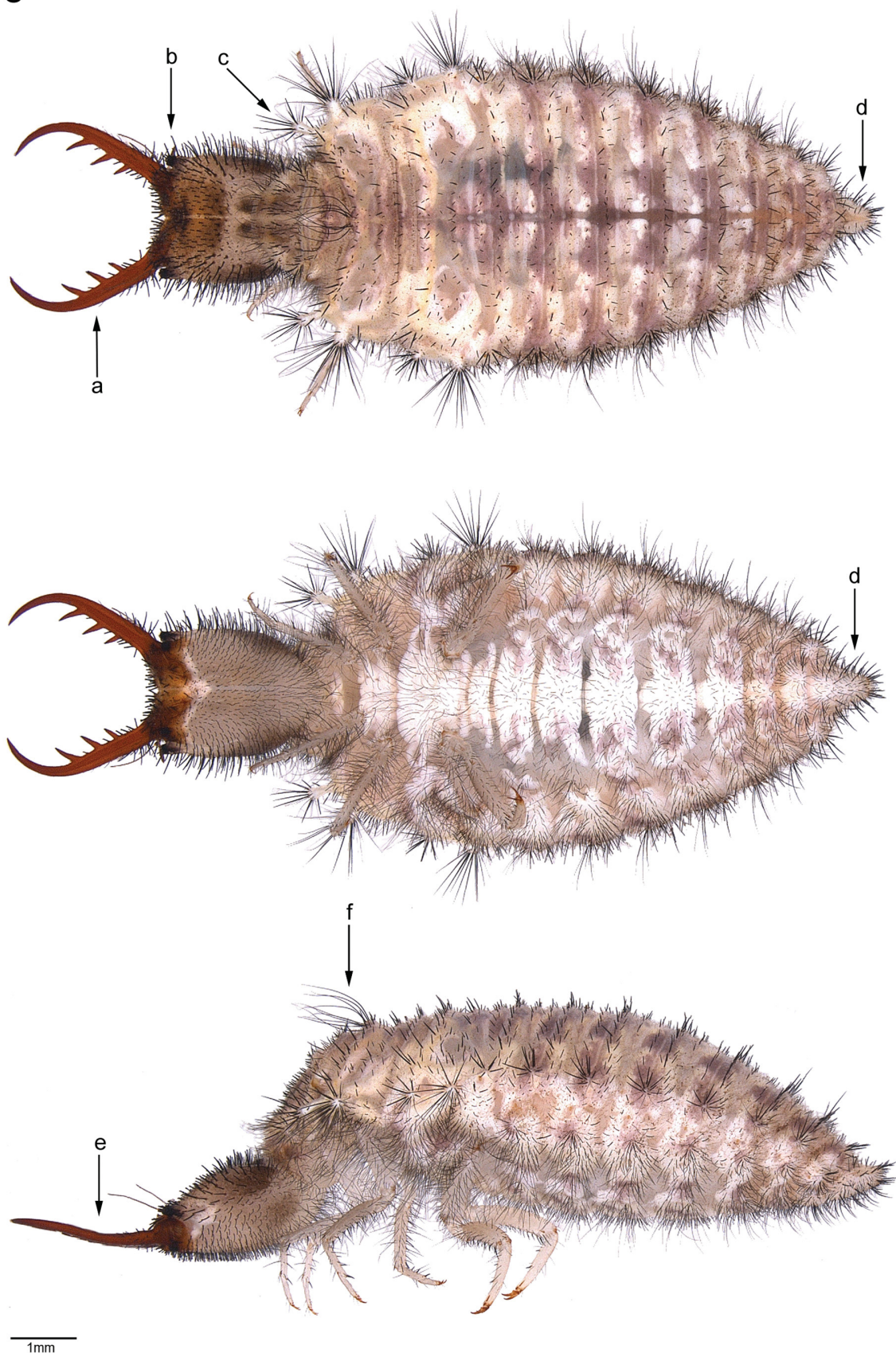
(Figs. 3A, 4A, 8)

The larva of this species was exhaustively described only once by Brauer (1867), as later accounts (Hagen 1873; Redtenbacher, 1884) are based on this study. Afterwards only few records about the finding of the larva exist (Roubal 1936; Kelner-Pillault 1967; Steinmann 1967). Gepp & Hölzel (1989) and Gepp (2010) reported the occasional synanthropy of this species and some behavioural traits.

**Examined specimen. Italy.** Emilia Romagna, Castel d'Aiano (Bologna), tree hole on chestnut, III.2012 (L. Colacurcio), 1 L1 laboratory-reared to L3.



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**FIGURE 8.** *Dendroleon pantherinus* (Fabricius, 1787), 3<sup>rd</sup> instar larva (Italy: Emilia Romagna, Castel d'Aiano). Dorsal (above), ventral (middle) and lateral (below) view; a–f: diagnostic characters, see species description.

**Description of 3<sup>rd</sup> instar larva.** Size: BL 10.60 mm; HL 2.49 mm, HW 2.01 mm, ML 1.79 mm, HW/HL 0.81, ML/HL 0.72. General colouring very pale, whitish pink without contrasting markings; head capsule reddish brown, ocular tubercles black, lateral sides of the head darker, ventral side pale; mandibles reddish brown; legs pale; body covered by black setae and thinner whitish bristles. Head longer than wide, with small ocular tubercles (Fig. 8b); mandibles bent upward (Fig. 8e), shorter than the head capsule and armed with long teeth (Fig. 8a); interdental mandibular setae: (4)(1)(1)(0); few short setae are disposed on the external margin of the mandibles. Pronotum covered by black setae (Fig. 4A); thoracic setiferous processes prominent (Fig. 8c); mesonotum with a characteristic tuft of black hair-like setae holding detritus in live specimens (Fig. 8f). IX abdominal segment sub-conical in shape (Fig. 8d); IX abdominal sternite longer than wide, provided with long setae (Fig. 3A).

**Bio-ecology.** *D. pantherinus* is a poorly known species associated with temperate woods of broadleaves, apparently avoiding arid biotopes; in Italy this antlion is reported from the sea level to mountains thus appearing relatively adaptable. The larvae were collected on trees, in tree holes filled with dry detritus and under barks, moreover they are remarkably able to colonize human buildings in proximity of woods, where they hide in sheltered corners (Gepp & Hölzel 1989; Gepp 2010). Brauer (1867) implied that the larvae could also be found in the soil of pine woods but it is probably a speculation not supported by actual findings. The presence of specimens in artificial structures suggests that, at least potentially, it is able to colonize different kinds of cavities in forested habitats or in their proximity. The larva is an extremely motionless ambush predator, normally staying completely burrowed and covering the body with debris.

**Distribution.** Europe (except the Iberian Peninsula) and Caucasus; Asian records refer to closely related species (Krivokhatsky 2011).

**Remarks.** The larva of this species is unmistakable and the only other European member of the tribe is *Tricholeon relictus* Hölzel & Monserrat, 2002, distributed in southern Spain. Despite the larva of this species is unknown, the South African species of *Tricholeon* differ from *Dendroleon* in the development of thoracic setiferous processes and teeth (Mansell 1988; Stange 2004).

## Tribe Nemoleontini Banks, 1911

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule with prominent ocular tubercles; mandibles usually equipped with three parallel teeth; apical tooth at least as long as the median tooth, often longer; labial palpi ordinarily four-articulated, segments 2–4 longer than the basal width of the mandible. Mesothoracic spiracles raised on tubercle. Thoracic setiferous processes pedunculated; in some genera also the abdomen provided with peduncolated setiferous processes. Odontoid processes on the VIII abdominal sternite present or absent according to the genus; IX abdominal sternite wider than long, bearing rastra equipped with digging setae.

**Biological notes.** The larvae are ambush hunters able to move both forward and backward.

**Comments.** This widespread tribe is the largest and most diverse of the whole family Myrmeleontidae, though poorly defined and lacking precise apomorphic characters (Stange 2004). The larvae of only a handful of genera are exhaustively described and the diagnostic characters are often not well defined, due to the considerable variation observed within the tribe. In particular, the larvae of some extra-Palaeartic genera considerably differ in the development of abdominal setiferous processes and, in some cases, in the reduction in the number of mandibular teeth and labial palpomeres (Miller & Stange 1985; Stange 2004).

## *Nemoleon* Navás, 1909

**Diagnosis.** Mandibles slightly upturned, relatively robust, equipped with 3 teeth; head and pronotum covered by white scale-like setae and dolichasters; pronotum dorsally covered by whitish scale-like setae; mesothoracic spiracles cone-shaped raised on tubercle; mesothorax with a short anterior pair of pedunculated setiferous processes, posterior pair sub-pedunculated; VIII sternite with odontoid processes; IX sternite equipped with rastra bearing 4 digging setae of which the internal one is shorter than the others.

**Examined species.** *N. notatus* (Rambur, 1842).

**Comments.** A mainly Afrotropical genus, *Nemoleon* comprises over 20 species, of which only 3 are



distributed in the western Palaearctic region (Hölzel 2002; Stange 2004). The larvae of this genus are described here for the first time.

### ***Nemoleon notatus* (Rambur, 1842)**

(Figs. 3B, 4B, 9)

The larva of this species is described for the first time.

**Examined specimen.** **Italy.** Sardinia, Alghero (Sassari), Capocaccia, rock overhang, XI.2012 (D. Badano), 1 L3, identification by biomolecular analysis.

**Description of 3<sup>rd</sup> instar larva.** Size: BL 8.50 mm; HL 2.05 mm, HW 1.85 mm, ML 1.66 mm, HW/HL 0.90, ML/HL 0.81. General colouring dark brown, dotted with small paler markings and a median light brown stripe running on the dorsal side, ventral side paler, mottled with dark brown; head capsule dark brown with darker areas on the sides, ventral side dark brown with a pair of darker markings at the base of the mandibles (Fig. 9f); antennae black; mandibles dark brown, internal margin paler; legs pale; setae of the body mainly black, interspersed with shorter white ones. Head slightly longer than wide; dorsal side covered by whitish scale-like setae (Fig. 9b); anterior margin of the labrum covered by white dolichasters (Fig. 9d); mandibles bent upward (Fig. 9i), relatively robust, shorter than the head capsule (Fig. 9a); interdental mandibular setae whitish: (3–4)(1)(1)(0); sparse black setae are disposed on the external margin of the mandible; labial palpi covered by white dolichasters (Fig. 9g). Pronotum covered by white scale-like setae (Fig. 4B, 9c); first pair of mesothoracic setiferous processes white (Fig. 9e). Abdominal spiracles slightly raised; IX abdominal sternite ventrally equipped with a pair of spiniform setae; rastra prominent, bearing 4 digging setae of which the internal seta is the shortest (Figs. 3B, 9h).

**Bio-ecology.** A poorly known species, *N. notatus* is associated with open arid environments such as savannahs, while in Europe this seldom collected antlion is mainly reported from arid coastal sites. In Sardinia, this species lives in arid and rocky scrublands. The only known larva was discovered buried under a rock overhang.

**Distribution.** A widely distributed afrotropical taxon reaching North Africa, the Middle East and southernmost western Europe (Spain, Balearic Islands and Sardinia).

**Remarks.** This species is the only member of the genus whose larva is known, comprising the only other European congener, *N. poecilopterus* (Stein, 1863) distributed from south Italy eastward (Stange 2004). The larva of *N. notatus* is easily recognizable from all the other known European members of the tribe thanks to the peculiar chaetotaxy of the head and pronotum.

### ***Creoleon* Tillyard, 1918**

**Diagnosis.** Mandibles relatively short and stout, equipped with 3 teeth, distance between the basal and median teeth smaller than that between the median and apical teeth; pronotum covered by sparse short setae; mesothoracic spiracles raised on a very short tubercle; first pair of mesothoracic setiferous processes sub-pedunculated, second pair sessile; VIII sternite provided with odontoid processes; IX sternite equipped with an anterior group of digging setae on the ventral surface and two rastra each bearing 4 digging setae.

**Examined species.** *C. lugdunensis* (Villers, 1789).

**Comments.** The genus *Creoleon* comprises 58 known species and it is widely distributed in Eurasia and Africa (Stange 2004). The only described larvae belong to the commonest European species: *C. lugdunensis* (Villers, 1789) (Steffan 1965, 1975) and *C. plumbeus* (Olivier, 1811) (Willmann 1977; Krivkhatsky 2011).

### ***Creoleon lugdunensis* (Villers, 1789)**

(Figs. 1E, 3D, 4D, 10)

The larva of this species was described and illustrated by Steffan (1965, 1975).

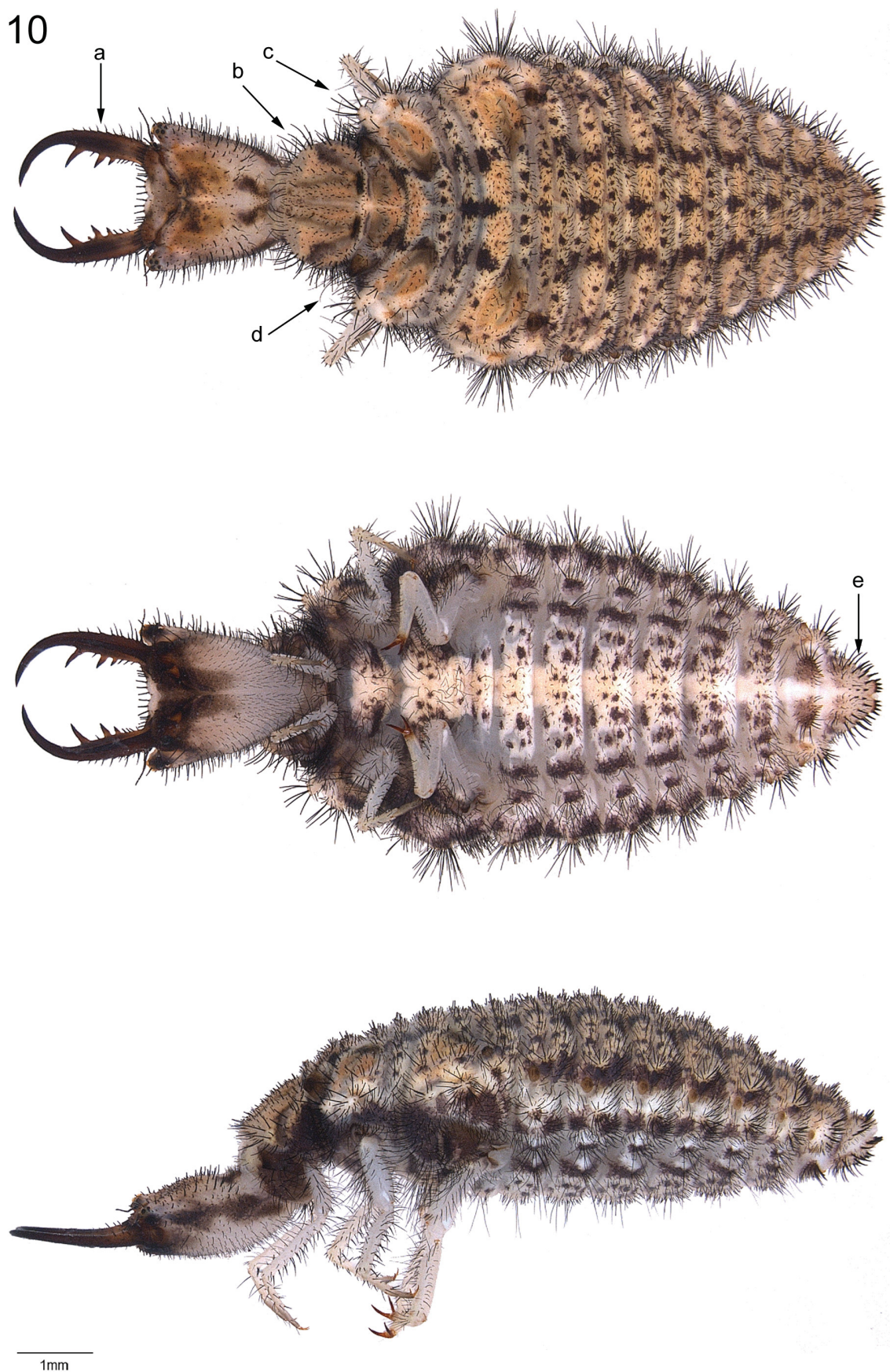
**Examined specimens.** **Italy.** Campania, 9 L3 laboratory-reared from a female collected at Boscotrecase (Napoli), VI.2010 (C. Labriola); 5 L3 laboratory-reared from a female collected in the same locality, VI.2011.

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**FIGURE 9.** *Nemoleon notatus* (Rambur, 1842), 3<sup>rd</sup> instar larva (Italy: Sardinia, Alghero, Capo Caccia). Dorsal (above), ventral (middle) and lateral (below) view; a–i: diagnostic characters, see species description.





**FIGURE 10.** *Creoleon lugdunensis* (Villers, 1789), 3<sup>rd</sup> instar larva (Italy: Campania, Boscotrecase). dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

Sicily, 2 L3 laboratory-reared from a female collected at Mazara del Vallo (Trapani), Gorgi Tondi, Mediterranean shrubland, IX.2010 (R. A. Pantaleoni).

**Description of 3<sup>rd</sup> instar larva.** Size (based on 16 specimens): BL 9.85 mm; HL 2.58 mm (2.39–2.73), HW 2.17 mm (2.13–2.28), ML 1.90 mm (1.76–2.05), HW/HL 0.84, ML/HL 0.74. General colouring brown with darker markings, ventral side paler with a dark pattern; head capsule brown with dark markings on the sides, ventral side with darker median areas; mandibles dark brown with blackish apex; legs pale; setae of the body black. Head longer than wide; mandibles noticeably robust, shorter than the head capsule (Fig. 10a); basal tooth closer to the median tooth and half of its size; interdental mandibular setae: (~4)(0–1)(1)(0); short setae are present on the external margin of the mandible. Pronotum covered by short setae (Figs. 4D, 10b); mesothoracic setiferous processes sub-pedunculated (Fig. 10c). Mesothoracic and abdominal spiracles brown, mesothoracic spiracle on a stout tubercle (Fig. 10d). VIII abdominal sternite with odontoid processes; IX sternite ventrally equipped with few digging setae, rastra well developed, each bearing 4 digging setae longer externally (Figs. 3D, 10e).

**Bio-ecology.** *C. lugdunensis* colonizes xeric grasslands and meadows, as it is favored by the presence of sand-like substratum, thus it is often common on back dunes or fossil dunes. The larvae prefer exposed conditions, often buried among herbaceous vegetation and far from trees.

**Distribution.** Western Mediterranean species distributed in western Europe and North Africa.

**Remarks.** The European species of the genus *Creoleon* need to be revised. The status of the Thyrrenian endemism *C. corsicus* (Hagen, 1860) is unclear, as well the status of the populations of South Iberia with spotted wings attributed in the past to *C. submaculosus* (Rambur, 1842) and *C. v-nigrum* (Rambur, 1842). For this reason, all the specimens studied are from the Thyrrenic coast of Italy and Sicily (typical *C. lugdunensis*). The only other member of the genus whose larvae are known is the eastern species *C. plumbeus*, although the existing descriptions (Willmann 1977; Krivokhatsky 2011) are not adequate to differentiate it from *C. lugdunensis*. The larvae of *C. lugdunensis* are recognizable from other genera of Nemoleontini thanks to the stocky mandibles, noticeably shorter than the head capsule.

## ***Macronemurus* A. Costa, 1855**

**Diagnosis.** Mandibles relatively strong, equipped with 3 equidistant teeth; setae covering the pronotum disposed in parallel rows; mesothoracic spiracles cone-shaped, raised on tubercle; thoracic setiferous processes pedunculated; VIII abdominal sternite with odontoid processes; IX abdominal sternite with rastra bearing digging setae of comparable length, with a shorter internal pair.

**Examined species.** *M. appendiculatus* (Latreille, 1807).

**Comments.** A mainly afrotropical genus with few members in the Palaearctic and in India, *Macronemurus* comprises 34 species (Stange 2004). The preimaginal stages of this genus are undescribed, except for a not diagnostic description of the 1<sup>st</sup> instar larva of *M. appendiculatus* (Insom *et al.* 1985).

## ***Macronemurus appendiculatus* (Latreille, 1807)**

(Figs. 1C, 3F, 4F, 11)

The 1<sup>st</sup> instar larva of this species was concisely described and illustrated by Insom *et al.* (1985), not providing any diagnostic character.

**Examined specimens. France.** Gard, Pompignan, scrubland, VII.2011 (B. Michel & D. Badano), 1 L3. **Italy.** Liguria, 1 L3 laboratory-reared from a female collected at Pompeiana (Imperia), scrubland, VII.2010 (D. Badano). Liguria, Cipressa (Imperia), Colla Caravella, at the base of a pine tree, 1 L1 laboratory-reared to adult (D. Badano). Sardinia, Sassari (Sassari), Li Punti, VII.2010 (D. Badano), 1 L2 and 1 L3 laboratory-reared to adult. Sardinia, Alghero (Sassari), the base of arenaceous escarpment, VIII.2010 (D. Badano), 1 L3. Sardinia, Alghero (Sassari), Capocaccia, coastal juniper thicket, IX.2011 (D. Badano), 1 L3; same locality, IV.2011, 1 L3; same locality, V.2012, 4 L3 and 2 L3 laboratory-reared to adults. Sardinia Alghero (Sassari), Carabuffas, 3 L3 laboratory-reared from a female collected in the field (R. A. Pantaleoni).



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**FIGURE 11.** *Macronemurus appendiculatus* (Latreille, 1807), 3<sup>rd</sup> instar larva (Italy: Sardinia, Alghero, Capo Caccia). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 13 specimens): BL 8.06 mm; HL 1.93 mm (1.79–2.11), HW 1.72 mm (1.60–1.94), ML 1.67 mm (1.43–2.00), HW/HL 0.89, ML/HL 0.86. General colouring yellowish brown with a dark brown pattern, markings of the dorsal side regularly disposed creating three lines, ventral side very pale, yellowish or whitish; head capsule brown, darker than the body with dark markings on the sides, ventral side of the head very pale except a dark area at the base of the mandibles; antennae black; jaws dark brown; legs pale; setae of the body black. Head a little longer than wide; mandibles shorter than the head capsule and relatively robust (Fig. 11a); interdental mandibular setae: (~4)(1)(1)(0). Pronotum covered by 4 parallel rows of setae with only very small setae interspersed between them (Fig. 4F); mesothoracic spiracles conical, reddish brown (Fig. 11b). Abdominal spiracles slightly raised; IX abdominal sternite covered by long digging setae; rastra prominent, bearing 4 subequal digging setae of which the internal seta is the shortest (Figs. 3F, 11c).

**Bio-ecology.** *M. appendiculatus* is a very common species in south-western Europe, associated with arid grasslands and low scrublands. The larvae live in the soil in exposed conditions, among herbaceous plants and rocks; they also colonize rock crevices filled with fine substratum. Occasionally they are buried at the base of escarpments or isolated trees.

**Distribution.** Typical western Mediterranean faunal element, widely distributed in south-western Europe and North Africa.

**Remarks.** The larval stages of the other members of the genus *Macronemurus*, including the east Mediterranean vicariant species *M. bilineatus* Brauer, 1868, still need to be discovered. The larvae of *M. appendiculatus* closely resemble the yellowish species of *Neuroleon*, often sharing the same habitat, although they are easily distinguishable due to the proportionally stouter mandibles, the chaetotaxy of the pronotum and the digging setae of the IX sternite.

## ***Distoleon* Banks, 1910**

**Diagnosis.** Mandibles equipped with 3 equidistant teeth; pronotum covered by large setae interspersed with spiniform bristles; mesothoracic spiracles raised on tubercle; first pair of mesothoracic setiferous processes pedunculated, second pair sub-pedunculated; VIII sternite with odontoid processes; IX sternite with two prominent rastra each bearing 4 sub-equal digging setae.

**Examined species.** *D. tetragrammicus* (Fabricius, 1798).

**Comments.** The genus *Distoleon* is a large genus, comprising at least 120 species distributed all across the Old World (Stange 2004). However, the larval stages are known only for the European *D. tetragrammicus* (Fabricius, 1798) (see below) and *D. annulatus* (Klug, 1834) (Acevedo *et al.* 2013) and for few Asiatic species (Stange *et al.* 2003; Stange 2004).

## **Key to larvae of the European species of *Distoleon***

1. Body colour dark brown, dorsal side of the head capsule unmarked, ventral side of the head with large markings (Fig. 12) . . . . . *D. tetragrammicus*
- Body colour ochre, dorsal side of the head capsule with large black markings, ventral side of the head unmarked . . . . . *D. annulatus* (from Acevedo *et al.* 2013)

## ***Distoleon tetragrammicus* (Fabricius, 1798)**

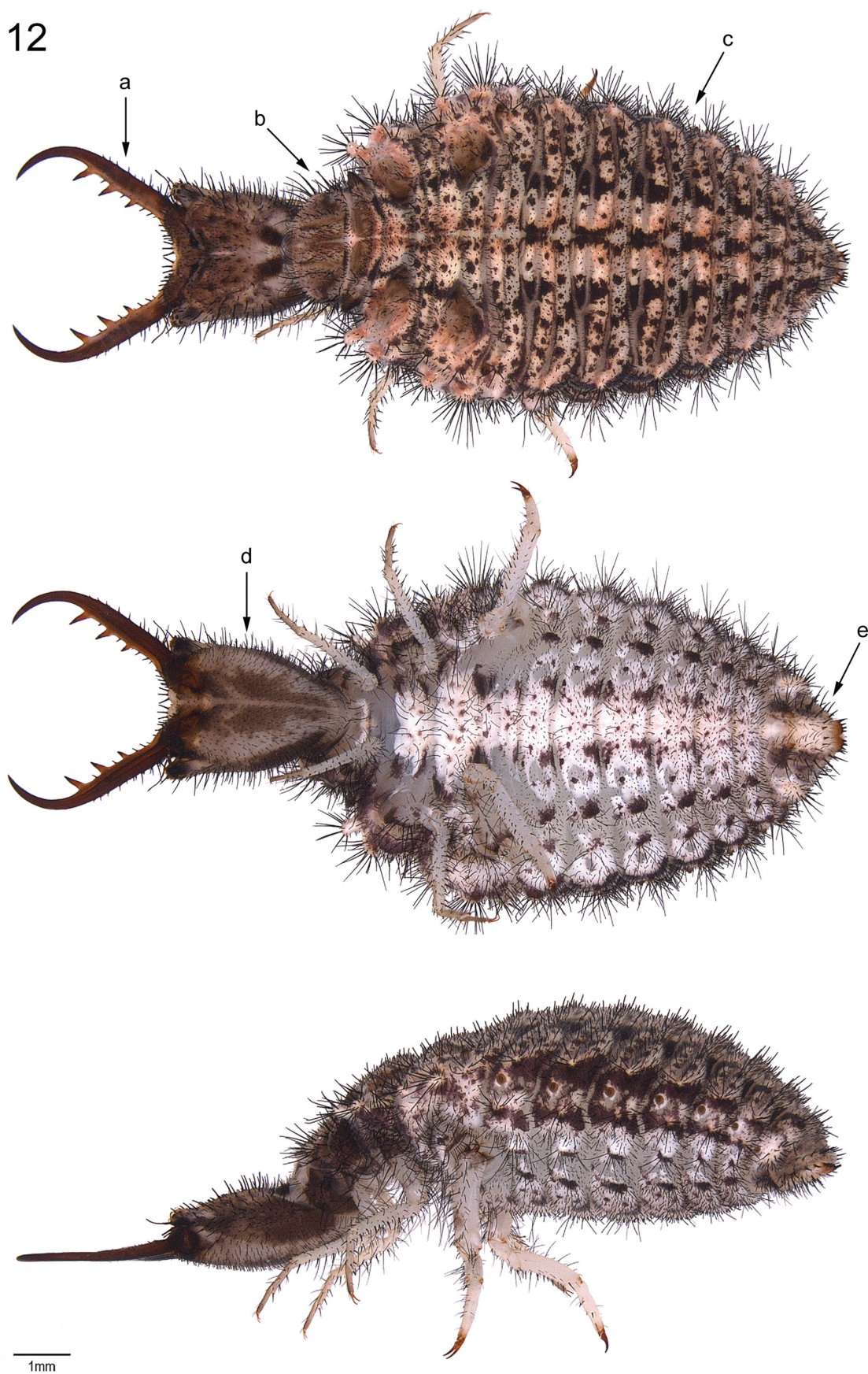
(Fig. 3C, 4C, 12)

The first report about a not pit-building antlion larva regards almost surely this species (Réaumur 1742; Bonnet 1780) but the first accurate scientific description was realized much later by Brauer (1854), subsequently it was redescribed many times (Hagen 1873; Redtenbacher 1884; Steffan 1975; Satar *et al.* 2006, Krivokhatsky 2011).

**Examined specimens. France.** Gard, Générac, arenaceous escarpment, VIII.2011 (D. Badano), 15 L1: 10 laboratory-reared to L3, 5 laboratory-reared to adults. **Italy.** Val d'Aosta, Aymavilles (Aosta), Pont d'Ael, rock overhang in arid meadow, VIII.2011 (D. Badano), 1 L3. Veneto, Bovolone (Verona), V.2010 (F. Sanna), 1 L3. Liguria, Perinaldo (Imperia), stone wall, VII.2011 (D. Badano), 3 L3 and 1 L3 laboratory-reared to adult. Liguria, Pompeiana (Imperia), rock escarpment, VII.2010 (D. Badano), 1 L3. Liguria, Cipressa (Imperia), Mediterranean



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**FIGURE 12.** *Distoleon tetragrammicus* (Fabricius, 1798), 3<sup>rd</sup> instar larva (France: Gard, Générac). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

scrubland, under pine trees, I.2012 (D. Badano), 4 L3. Tuscany, Elba, Portoferraio (Livorno), IX.2010 (L. Forbicioni), 1 L3. Lazio, Rocca Priora (Roma), X.2011 (M. Gigli), 1 L3. Sardinia, Berchidda (Sassari), cork oak wood, pitfall trap, VII.2010, (M. Verdinelli & S. Cossu), 1 L3. **Greece.** Corfu, Kato Pauliana, rock overhang, V.2012 (D. Badano), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 24 specimens): BL 10.60 mm; HL 3.00 mm (2.41–3.33), HW 2.45 mm (2.22–2.72), ML 2.54 mm (2.24–2.76), HW/HL 0.82, ML/HL 0.85. General colouring dark brown with darker markings, abdomen with a dorsal median stripe with a characteristic pattern (Fig. 12c), ventral side paler with dark brown markings; head capsule dark brown, lateral and ventral sides with extensive dark markings (Fig. 12d); mandibles dark brown; legs yellowish or whitish; setae of the body black. Head longer than wide; mandibles comparatively strong, shorter than the head capsule (Fig. 12a); interdental mandibular setae: (3–4)(1)(1)(0). Pronotum covered by large setae interspersed with short bristles (Figs. 4C, 12b). Mesothoracic and abdominal spiracles brown. VIII abdominal sternite with odontoid processes; IX sternite with a ventral pair of spiniform setae and with two small rastra each equipped with 4 sub-equal digging setae (Figs. 3C, 12e).

**Bio-ecology.** *D. tetragrammicus* is an euryoecious species and its larvae are able to colonize any microhabitat with presence of dry and fine substratum, thus it is very abundant and widespread. In southern Europe it is found from coastal dunes to montane forests, in a large array of habitats, always in dry conditions even if punctiform. The larvae appear avoid exposed sites, preferring protected niches such as at the base of trees or shrubs, under rocks or in their proximity. Therefore they are absent from open coastal sand dunes while they are common on back dunes with conspicuous vegetation growing. *D. tetragrammicus* larvae are frequent in rocky microhabitat such as escarpments or under overhangs and they are able to colonize similar artificial structures, such as stone walls.

**Distribution.** Widespread in the western Palaearctic, only avoiding cold climates and true deserts.

**Remarks.** The larva of *D. tetragrammicus* differs from *D. annulatus*, the only other European congener, for its overall dark brown colouring and pattern while *D. annulatus* is much paler, sand-like in colour, with contrasting dark markings (Acevedo *et al.* 2013). The pigmentation pattern of the dorsal side of the abdomen, composed by a median series of contiguous circular markings is a constant character in this species allowing the identification of all larval stages of *D. tetragrammicus*. Finally, the relatively conspicuous size of this antlion permits an immediate distinction of the 3<sup>rd</sup> instar larvae from the other known member of the tribe.

## *Neuroleon* Navás, 1909

**Diagnosis.** Anterior margin of the clypeo-labrum with a small median incision; mandibles equipped with 3 teeth; pronotum covered by long setae and by dolichasters; mesothoracic spiracles conical, raised on tubercle; abdominal spiracles slightly raised; first pair of mesothoracic setiferous processes pedunculated, second pair sub-pedunculated; VIII sternite with slightly developed odontoid processes; IX sternite equipped with two short rastra each bearing 4 digging setae of which the internal seta is less than a half the size of the others.

**Examined species.** *N. arenarius* Navás, 1904; *N. assimilis* (Navás, 1914); *N. egenus* (Navás, 1914); *N. microstenus* (McLachlan, 1898); *N. nemausiensis* (Borkhausen, 1791); *N. ochreatus* (Navás, 1904).

**Comments.** *Neuroleon* is a large genus, including 123 species mainly distributed in the Afrotropical and western Palaearctic regions, with relatively few exponents in the Oriental region (Michel & Akoudjin 2012). The larvae are very poorly known and they have been certainly described only for *N. egenus*, *N. microstenus* and *N. ochreatus* (Auber 1956a; Steffan 1965, 1971, 1975; Devetak *et al.* 2010), see also under *N. nemausiensis*. The larvae of this genus are very homogeneous in overall morphology, lacking striking morphological differences useful to discriminate them from other genera of Nemoleontini and among themselves.

## Key to the known larvae of *Neuroleon*

- |   |   |                       |
|---|---|-----------------------|
| 1 | Dorsal side of the head capsule mostly covered by large contiguous black markings (Fig. 16) .....                               | 2                     |
| - | Dorsal side of the head capsule without extended black markings (Fig. 13–15, 17) .....  | 3                     |
| 2 | Ventral side of the head capsule pale; general colour of the body whitish .....   | <i>N. ochreatus</i>   |
| - | Ventral side of the head capsule infuscated; general colour of the body ochre (Fig. 16) .....                                   | <i>N. microstenus</i> |
| 3 | Ventral portion of the head capsule with a pair of median markings (except those on the gular area); general colour of the body |                       |



|   |  |                        |
|---|--|------------------------|
|   | brown (Figs. 14, 15) . . . . .   | 4                      |
| - | Ventral portion of the head capsule without a pair of median markings (except those on the gular area); general colour of the body ochre (Figs. 13, 17) . . . . .  | 5                      |
| 4 | Mandibles relatively thin, distance between base and the basal tooth equal to that between the basal and apical teeth; ventral side of the head capsule with a median pair of separated spots; labial palpi dark (Fig. 14). . . . .                | <i>N. assimilis</i>    |
| - | Mandibles relatively robust, distance between base and basal tooth smaller than that between the basal and apical teeth; ventral side of the head capsule with a median pair of contiguous parallel stripes; labial palpi pale (Fig. 15) . . . . . | <i>N. egenus</i>       |
| 5 | Dorsal side of the head with an anterior pair of brown markings disposed from the antennal pit to the posterior V-shaped markings (Fig. 13). . . . .   | <i>N. arenarius</i>    |
| - | Dorsal side of the head without an anterior pair of dark markings (Fig. 17) . . . . .  | <i>N. nemausiensis</i> |

### ***Neuroleon arenarius* Navás, 1904**

(Fig. 13)

The larva of this species is described for the first time.

**Examined specimens. Italy.** Lazio, Roma, Monte Mario, escarpment, VII.2010 (A. Alfonsi & C. Cesaroni), 3 L3 and 1 L3 laboratory-reared to adult; same locality, IX.2010, 1 L3. Sardinia, Alghero (Sassari), Lazzaretto, arenaceous escarpment, IX.2010 (D. Badano), 2 L1 laboratory-reared to L3. Sardinia, Cagliari (Cagliari), Molentargius, rock overhang, IX.2010 (D. Badano), 2 L3 and 2 L3 laboratory-reared to adult. **Greece.** Corfu, Korission lake, sand dunes, V.2012 (D. Badano), 1 L3 laboratory-reared to adult.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 8 specimens): BL 8.20 mm; HL 1.80 mm (1.68–1.86), HW 1.44 mm (1.35–1.52), ML 1.57 mm (1.37–1.72), HW/HL 0.80, ML/HL 0.87. General colouring ochre, sand-like, with brown markings and spots; head capsule with distinctive dorsal brown markings: 2 anterior convergent stripes running from the antennal pits toward the middle dorsal portion of the head, reaching 2 posterior markings and creating a V-shaped pattern (Fig. 13b); margins of the head with brown stripes, ventral side of the head pale with a darker area at the insertion of the mandibles (Fig. 13c); labial palpi dark brown (Fig. 13d); mandibles brown; legs pale; setae of the body mostly black. Head longer than wide; dorsal side of the head capsule thickly covered by pale dolichasters; mandible comparatively strong, shorter than the head capsule (Fig. 13a); interdental mandibular setae (~4)(1)(1)(0); sparse setae are present on the external margin of the mandible. Mesothoracic spiracles reddish-brown. IX abdominal sternite with two short rastra each bearing 4 digging setae, internal seta shorter than the others (Fig. 13e).

**Bio-ecology.** This species lives in open Mediterranean environments such as scrublands, open woods, grasslands and dunes. The larvae of this species have been found under rock overhangs, on escarpments of friable rocks or compacted sand hiding in recesses or burrows and even in coastal sand dunes in shaded conditions.

**Distribution.** Reported for southern Europe, North Africa and Israel.

**Remarks.** The pattern on the dorsal side of head is unique of this species.

### ***Neuroleon assimilis* (Navás, 1914)**

(Figs. 3E, 14)

The larva of this species is described for the first time.

**Examined specimens. Greece.** Corfu, Agia Varvara, V.2012 (D. Badano), 1 L3 laboratory-reared to adult. Corfu, Acharavi, rock escarpment, V.2012 (D. Badano), 2 L3. Corfu, Lafki, rock escarpment, V.2012 (D. Badano), 1 L3 and 1 L3 laboratory-reared to adult. Corfu, Kato Pavliana, rock overhang, V.2012 (D. Badano), 1 L3. Corfu, Kato Garouna, rock overhang, V.2012 (D. Badano), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 5 specimens): BL 8.52 mm; HL 2.21 mm (1.96–2.33), HW 1.75 mm (1.70–1.87), ML 2.00 mm (1.9–2.08), HW/HL 0.79, ML/HL 0.90. General colouring pale brown mottled with dark brown, ventral side very pale with conspicuous dark brown markings; head capsule dorsally dark brown with a darker V-shaped marking on the occipital area (Fig. 14b), lateral sides with dark brown markings, ventral side of the head paler with a pair of elongated marking in the gular area, and two median dark spots (fainted in some individuals) (Fig. 14c); labial palpi dark brown (Fig. 14d); mandibles brown with basal dark spots; legs pale; setae of the body black. Head longer than wide; dorsal side of the head capsule with a thick covering of

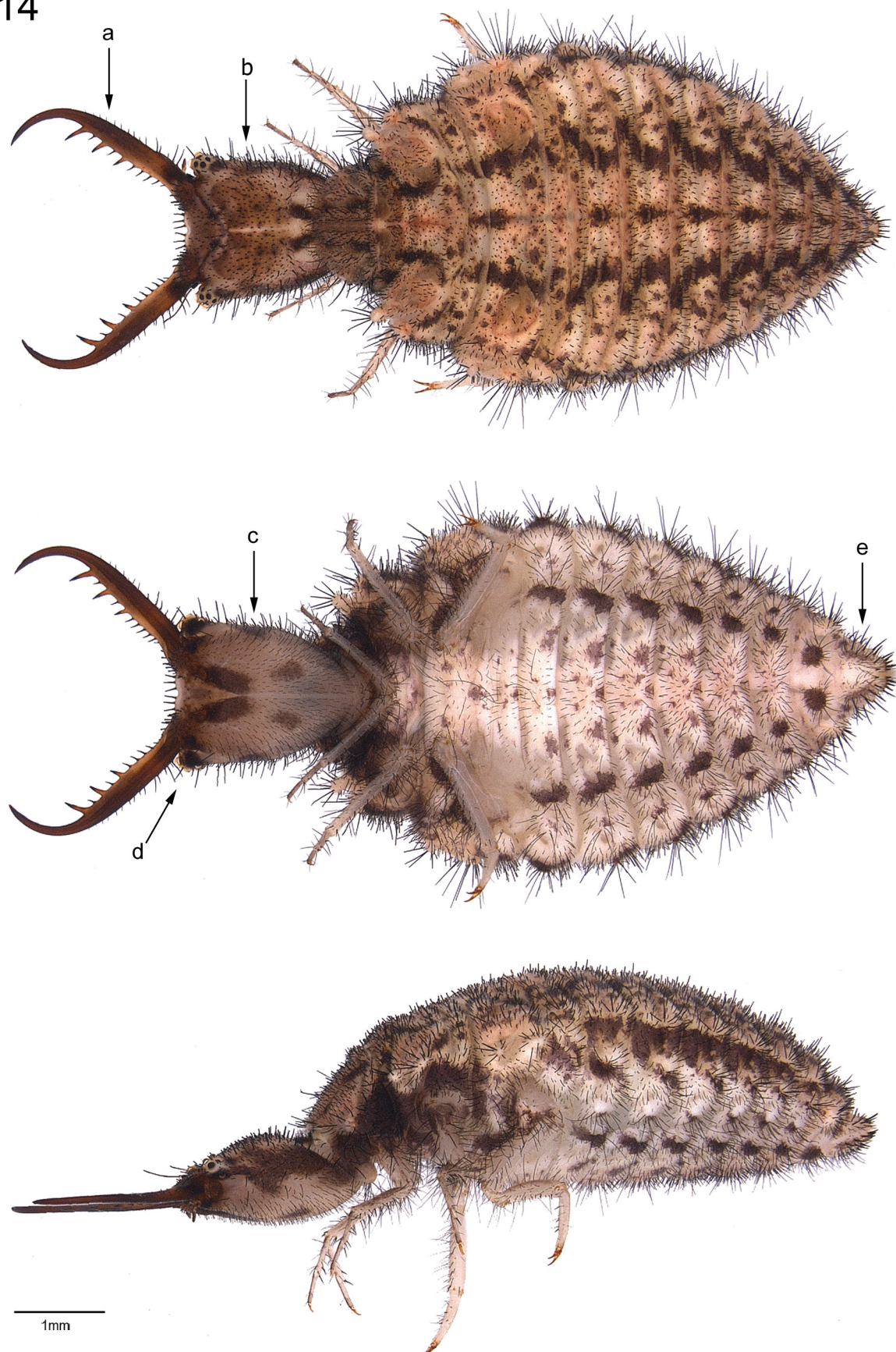
13



**FIGURE 13.** *Neuroleon arenarius* (Navás, 1904), 3<sup>rd</sup> instar larva (Italy: Sardinia, Alghero, Lazzaretto). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.



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**FIGURE 14.** *Neuroleon assimilis* (Navás, 1915), 3<sup>rd</sup> instar larva (Greece: Corfu, Kato Pauliana). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

short dolichasters; mandibles comparatively thin, slightly shorter than the head capsule (Fig. 14a); distance between mandible base and basal tooth equal to that between basal and apical teeth; interdental mandibular setae (+5)(1)(1)(0). Mesothoracic spiracles brown. IX abdominal sternite with two rastra equipped with 4 digging setae, internal seta shortest (Figs. 3E, 14e).

**Bio-ecology.** The biology of this species is unknown. The larvae were collected on escarpments and under rock overhangs in Mediterranean environments such as open woods, scrublands, garrigues and arid grasslands.

**Distribution.** This species is reported from Greece, Anatolia, Syria, Iran and Armenia.

**Remarks.** The larva of *N. assimilis* is identifiable thanks to the comparatively straight and thin mandibles and the pair of spots on the ventral side of the head.

### ***Neuroleon egenus* (Navás, 1914)**

(Fig. 15)

The larva of *N. egenus* was described and illustrated by Steffan (1965, 1971, 1975), in the first description wrongly identified as *N. nemausiensis* (see under this species).

**Examined specimens. France.** Hérault, Carnon la plage, sand dunes, VII.2011 (D. Badano), 4 L3 laboratory-reared to adult. Gard, Beauvoisin, relict sand dunes, VIII.2011 (D. Badano), 4 L3 and 2 L3 laboratory-reared to adult. Gard, Générac, relict sand dunes, VIII.2011 (D. Badano), 2 L3. **Italy.** Liguria, Cipressa (Imperia), open pine wood, IX.2010 (D. Badano), 1 L3. Lazio, Roma, Insugherata, IX.2010 (A. Alfonsi & C. Cesaroni), 3 L3. Sardinia, Sassari (Sassari), urban park, XI.2011 (D. Badano), 1 L3. Sardinia, Platamona (Sassari), pine wood on back dunes, XII.2010 (D. Badano), 4 L3. Sardinia, Alghero (Sassari), pine wood on back dunes, V.2010 (D. Badano), 1 L3 laboratory-reared to adult. Sardinia, Dolianova (Cagliari), cork oak wood, V.2010 (D. Badano), 2 L3 and 1 L3 laboratory-reared to adult. **Greece.** Corfu, Acharavi, scrubland, V.2012 (D. Badano), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 18 specimens): BL 8.20 mm; HL 1.96 mm (1.68–2.22), HW 1.58 mm (1.38–1.99), ML 1.74 mm (1.41–1.99), HW/HL 0.81, ML/HL 0.89. General colouring brown with dark brown markings, ventral side paler with a dark pattern; head capsule with small markings on the dorsal side, antennal pits bordered by dark brown markings, occipital area with a V-shaped marking, lateral sides with conspicuous dark markings (Fig. 15b), ventral side of the head capsule with dark spots bordering the gula and a median pair of short parallel stripes (slightly faded in some individuals) (Fig. 15c); labial palpi pale brown (Fig. 15d); mandibles brown with a dark brown spot at the base; legs pale; setae of the body black. Head longer than wide; dorsal side of the head capsule covered by short and relatively sparse dolichasters; mandibles slightly shorter than the head capsule (Fig. 15a); interdental mandibular setae: (+4)(1)(1–rarely 2)(0). Mesothoracic spiracles brown. IX abdominal sternite with rastra each bearing 4 digging setae, internal seta is shorter than the others (Fig. 15e).

**Bio-ecology.** *N. egenus* is a relatively common and euryoecious species living in a diverse array of Mediterranean environments, from dunes to xeric woods, although it is associated with the presence of arboreal vegetation. The larvae require protected and shaded condition, such as at the base of trees where they can be noticeably abundant, buried into vegetal debris among roots. Larvae of this antlion also colonize other sheltered microhabitats, such as under rock overhangs or under shrubs. The larvae of this species are often found in small groups, in many cases composed by coetaneous specimens, probably suggesting a weak or absent dispersal behaviour from the original site of oviposition.

**Distribution.** Widespread along the Mediterranean Basin.

**Remarks.** The short parallel stripes on the ventral side of the head easily permit to discriminate this species from the congeners.

### ***Neuroleon microstenus* (McLachlan, 1898)**

(Fig. 16)

The 1<sup>st</sup> instar larva of this species was firstly described by Gepp (1974), while the other stages were investigated only recently by Devetak *et al.* (2010). See also under *N. nemausiensis*.



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**FIGURE 15.** *Neuroleon egenus* (Navás, 1915), 3<sup>rd</sup> instar larva (Italy: Liguria, Cipressa). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.

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**FIGURE 16.** *Neuroleon microstenus* (McLachlan, 1898), 3<sup>rd</sup> instar larva (Italy: Liguria, Bordighera, Mt. Nero). Dorsal (above), ventral (middle) and lateral (below) view; a–f: diagnostic characters, see species description.



**Examined specimens. Italy.** Liguria, Bordighera (Imperia), Monte Nero, rock crevices, VIII.2010 (D. Badano), 2 L3, identification by biomolecular analysis; same locality, VIII.2012, 2 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 4 specimens): BL 8.00 mm; HL 2.24 mm (1.81–2.51), HW 1.72 mm (1.57–1.82), ML 1.96 mm (1.90–2.10), HW/HL 0.77, ML/HL 0.87. General colouring light ochre with contrasting dark brown markings, ventral side pale with a dark pattern; head capsule with extensive dark markings, head dorsal side with a median pair of large dark markings creating a filled “V”, lateral sides completely dark (Fig. 16b), ventral side of the head dark brown with darker markings surrounding the gula (in one specimen the markings of the lateral sides prosecute ventrally) (Fig. 16d); labial palpi black (Fig. 16e); mandibles dark brown; legs pale; setae of the body black. Head longer than wide; dorsal side of the head capsule covered with sparse and very short dolichasters (Fig. 16c); mandibles almost as long as the head capsule (Fig. 16a); distance between the base of the mandible and basal tooth slightly smaller than that between the basal and apical teeth; interdental mandibular setae: (3–4)(1)(1)(0). Mesothoracic spiracles ochre. IX abdominal sternite with rastra equipped with 4 digging setae, internal seta shorter than the others (Fig. 16f).

**Bio-ecology.** A poorly known species, *N. microstenus* is usually reported for open Mediterranean environments, especially arid rocky scrublands. The larvae were collected at the base of shrubs and in rock crevices filled with sand.

**Distribution.** Widespread in the Mediterranean basin, notably lacking in the Iberian Peninsula.

**Remarks.** Besides the body colouring and the dark pattern of the head, *N. microstenus* is recognizable by means of the sparse short dolichasters covering the dorsal side of the head capsule. Another diagnostic character of this species is the dark colour of the ventral side of the head capsule, while in the other members of the genus it is normally pale.

### *Neuroleon nemausiensis* (Borkhausen, 1791)

(Figs. 4E, 17)

Auber (1956a) described some *Neuroleon* larvae collected in southern France as *N. nemausiensis*. Steffan (1965) wrongly attributed to *N. nemausiensis* the larvae of *N. egenus*, as stated by himself in a later paper (Steffan 1971), at the same time acknowledging the previous description of *N. nemausiensis* by Auber (1956a). Nevertheless the original account of Auber (1956a) does not agree with the specimens studied here, whose identity is verified by means of the reared adults, therefore it is not possible to speculate about the identity of the larvae observed by him. Conversely Steffan (1975) illustrated a larva as *N. microstenus* that shows a similar head pattern to the actual *N. nemausiensis*, however he did not rear it for identification. Consequently this is the first reliable description of the larva of *N. nemausiensis*.

**Examined specimens. Italy.** Liguria, Bordighera (Imperia), Monte Nero, rock crevices, VIII.2010 (D. Badano), 5 L3 and 2 L3 laboratory reared to adult. Sardinia, Alghero (Sassari), Capocaccia, juniper thicket, V.2010 (D. Badano), 1 L3; same locality, IX.2010, 3 L3 and 2 L3 laboratory-reared to adult; same locality, IX.2011, 3 L3 and 2 L3 laboratory-reared to adult; same locality, V.2012, 4 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 16 specimens): BL 8.11 mm; HL 1.94 mm (1.80–2.23), HW 1.53 mm (1.37–1.65), ML 1.61 mm (1.46–1.80), HW/HL 0.83, ML/HL 0.79. General colouring yellowish brown with dark brown markings, ventral side very pale without contrasting dark areas; dorsal side of the head capsule with large conspicuous V-shaped dark markings (Fig. 17b), antennal pits shrouded with dark brown, lateral sides with long dark markings, ventral side of the head completely pale except the dark brown labial area and a pair of dark markings bordering the gula (Fig. 17c); labial palpi dark brown (Fig. 17d); mandibles dark brown with a paler median area and a basal dark brown spot; legs pale; setae of the body black. Head longer than wide; dorsal side of the head capsule thickly covered by dolichasters; mandibles comparatively thin, slightly shorter than the head capsule (Fig. 17a); distance between the base of the mandible and basal tooth shorter than that between the basal and apical teeth; interdental mandibular setae: (+4)(1–2)(1)(0). Mesothoracic spiracles reddish brown. IX abdominal sternite with two rastra bearing 4 digging setae of which the internal seta is the shortest (Fig. 17e).

**Bio-ecology.** *N. nemausiensis* is a frequent species in warm and arid sites such as open woods and scrublands. The larvae appear relatively adaptable in microhabitat choice and they were discovered under rock overhangs, at the base of shrubs and among stones, apparently showing a preference to live in small rock pockets filled with fine detritus.

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**FIGURE 17.** *Neuroleon nemausiensis* (Borkhausen, 1791), 3<sup>rd</sup> instar larva (Italy: Sardinia, Alghero, Capo Caccia). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.



**Distribution.** A widespread species in the western Palaearctic in areas with Mediterranean climatic influences.

**Remarks.** As the other *Neuroleon*, the larva of *N. nemausiensis* is distinguishable thanks to the overall body colouring and pigmentation pattern of the head.

### *Neuroleon ochreatus* (Navás, 1904)

The larva of this species was described for the first time by Auber (1956a), followed few years later by Steffan (1965) who also included it in identification keys (Steffan 1971, 1975).

**Examined specimens. France.** Hérault, La Grande Motte, coastal sand dune, VII.2011 (D. Badano), 2 L3 laboratory-reared to adults.

**Description of 3<sup>rd</sup> instar larva.** Size (based on Steffan 1965): BL 8.64–12.40 mm, HL 1.62–1.80 mm, HW 1.62–1.89 mm, ML 1.62–1.89 mm. General colouring very pale, whitish grey with a dark pattern; dorsal side of the head capsule mostly covered by a pair black markings extending on the sides, a smaller black marking stains the tentorial pits, clypeo-labrum and area of the ocular tubercles unmarked, ventral side of the head very pale with a darker area at the insertion of the mandibles; labial palpi dark brown; mandibles brown with a dark apex; legs pale; setae of the body mostly black. Head longer than wide; mandibles comparatively long, at least as the head capsule; interdental mandibular setae (+4)(1)(1)(0); sparse setae on the external margin of the mandible. Mesothoracic spiracles whitish. Abdominal spiracles whitish; IX abdominal sternite with two rastra equipped with 4 digging setae, internal seta less than a half the size of the others.

**Bio-ecology.** A poorly known species mainly reported from warm and xeric environments such as coastal sand dunes, internal sandy deposits and river banks.

**Distribution.** Western Mediterranean faunal element, known for the Iberian Peninsula, France and Italy.

**Remarks.** The larva of *N. ochreatus* is recognizable from the congeners for the whitish body colour, the large dark markings covering most of the dorsal side of the head and the whitish spiracles.

### *Megistopus Rambur, 1842*

**Diagnosis.** Mandibles comparatively long, equipped with 3 pairs of teeth; pronotum covered by long setae; mesothoracic spiracles pronounced, raised on tubercle; thoracic setiferous processes pedunculated; odontoid processes of the VIII sternite atrophied or completely absent; IX sternite with rastra bearing 4 pairs of digging setae of which the internal pair is not over a quarter the others in length.

**Examined species.** *M. flavicornis* (Rossi, 1790), *M. lucasi* (Navás, 1912).

**Comments.** An exclusively western Palaearctic genus, *Megistopus* comprises 3 species: the widespread *M. flavicornis* (Rossi, 1790), *M. mirabilis* (Hölzel, 1980), known for a single specimen from Sinai and finally *M. lucasi* (Navás, 1912) reported from Algeria and Tunisia (H. Aspöck *et al.* 2001; Güsten 2003). The latter species was overlooked for a considerable time, being originally described as a member of the genus *Nelees* Navás, 1912 (now synonym of *Neuroleon* Navás, 1909), despite the correct genus placement was already recognized by Banks (1913). This interesting species is also present in Italy ([Bernardi] Iori *et al.* 1995; Letardi & Pantaleoni 1996; Letardi & Maltzeff 2001), although the Italian specimens were originally assigned to *M. mirabilis*. The larva of *M. flavicornis* is the only species of the genus whose larva is known (Steffan 1965; Cesaroni *et al.* 2010).

### Key to the larvae of *Megistopus*

- 1 Spiracles pedunculated; mesothoracic spiracles longer than the mesothoracic setiferous processes; dolichasters covering the clypeo-labrum and labial palps black; IX abdominal sternite without markings (Fig. 18). . . . . *M. flavicornis*
- Spiracles not pedunculated; mesothoracic spiracles shorter than the mesothoracic setiferous processes; dolichasters covering the clypeo-labrum and labial palps whitish; IX abdominal sternite with markings (Fig. 19). . . . . *M. lucasi*

### *Megistopus flavicornis* (Rossi, 1790)

(Fig. 18)

As the older reports actually refers to other species (Redtenbacher, 1884), the first description of the larva of *M. flavicornis* was realized by Steffan (1965). Later Cesaroni *et al.* (2010) redescribed exhaustively the larva of this species comparing it with the closely related *Gymnocnemia variegata*.

**Examined specimens.** **France.** Gard, Pompignan, dry stream sand deposits, VIII.2011 (D. Badano), 2 L2, 2 L3 laboratory-reared to adults. Gard, Beauvoisin, pinewood on internal sand dune, VIII.2011, (D. Badano), 1 L2, 2 L3 laboratory-reared to adults. **Italy.** Sardinia, Alghero (Sassari), pinewood on coastal dune, IV.2008 (C. Cesaroni), 4 L3; same locality, XI.2008, 2 L3. **Greece.** Chalkidiki, Mount Athos, VIII.2008 (L. Fancello), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 7 specimens): BL 10.25 mm; HL 2.35 mm (2.07–2.41), HW 1.75 mm (1.60–2.05), ML 2.16 mm (2.07–2.28), HW/HL 0.74, ML/HL 0.92. General colouring light brown, mottled with dark, ventral side pale with a dark pattern; head capsule with extensive dorsal dark markings, ocular tubercles black, ventral side of the head pale with the exception of dark markings surrounding the gula; mandibles reddish brown; legs pale; setae of the body black. Head longer than wide; anterior margin of the clypeo-labrum covered by black dolichasters (Fig. 18b); mandibles as long as the head capsule (Fig. 18a); interdental mandibular setae: (3–4)(1)(1)(0); labial palpi covered by black dolichasters (Fig. 18f). Pronotum thickly covered by black setae (Fig. 18d); mesothoracic spiracles raised on over-developed tubercles, considerably longer than the mesothoracic setiferous processes (Fig. 18c); thoracic setiferous processes pedunculated. Abdominal spiracles pedunculated and prominent, clearly visible from above (Fig. 18e); VIII abdominal sternite provided with reduced odontoid processes; IX sternite pale, without conspicuous lateral markings, rastra with the internal pair of setae less than a quarter of the others in size (Fig. 18g).

**Bio-ecology.** *M. flavicornis* is a relatively euryoecious species, reported for Mediterranean-like environments characterized by the presence of sand-like substratum such as coastal dunes, internal sandy deposits and river banks. The larvae are usually found in shaded conditions such as at the base of trees or in proximity of other shelters.

**Distribution.** Widespread in the Mediterranean basin, reaching Austria and Hungary in the north and Iran in the east.

**Remarks.** This antlion is distinguished by extremely developed spiracles, an unusual and rare character in the whole family Myrmeleontidae, therefore considered worth of generic value by Stange (2004). Nevertheless the discovery of the larva of *M. lucasi*, in which these structures are not overdeveloped, allows to consider this character as exclusive of *M. flavicornis*. Therefore, the larvae of the genus *Megistopus* differs from the closely related *Gymnocnemia* only in details of the mandibles and of the abdominal IX sternite.

### *Megistopus lucasi* (Navás, 1912)

(Figs. 3G, 4G, 19)

The larva of this rare species is described for the first time.

**Examined specimens.** **Italy.** Sardinia, Arbus (Oristano), Torre dei Corsari, coastal sand dunes, V.2010 (D. Badano), 1 L3 and 1 L3 laboratory-reared to adult; same locality, IV.2011, 4 L3 and 1 L3 laboratory-reared to adult. Sardinia, Chia (Cagliari), beach, XI.2011 (D. Badano), 2 L3 and 1 L3 laboratory-reared to adult.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 7 specimens): BL 9.48 mm; HL 2.27 mm (2.15–2.49), HW 1.86 mm (1.71–1.96), ML 1.98 mm (1.90–2.22), HW/HL 0.74, ML/HL 0.92. General colouring ochre with pink shades and mottled with dark brown, ventral side very pale with dark markings; head capsule with dark occipital markings, lateral sides with dark markings, ocular tubercles black, ventral side of the head pale except the gular area; mandibles orange; legs pale; setae mostly black except some white bristles in anterior portion of the body. Head longer than wide; anterior margin of the labrum covered by white dolichasters (Fig. 19c); mandibles slender, slightly shorter than the head capsule (Fig. 19a), distance between the base of the mandible and basal tooth larger than that between the basal and apical teeth; interdental mandibular setae: (2)(1)(1)(0); labial palpi covered by whitish dolichasters (Fig. 19e). Pronotum covered by sparse setae, anterior setae paler in colour (Figs. 4G, 19b); mesothoracic spiracles cylindrical, raised on tubercle but comparatively stout, shorter than the first pair of setiferous processes (Fig. 19d); mesothoracic setiferous processes pedunculated. Abdominal spiracles slightly

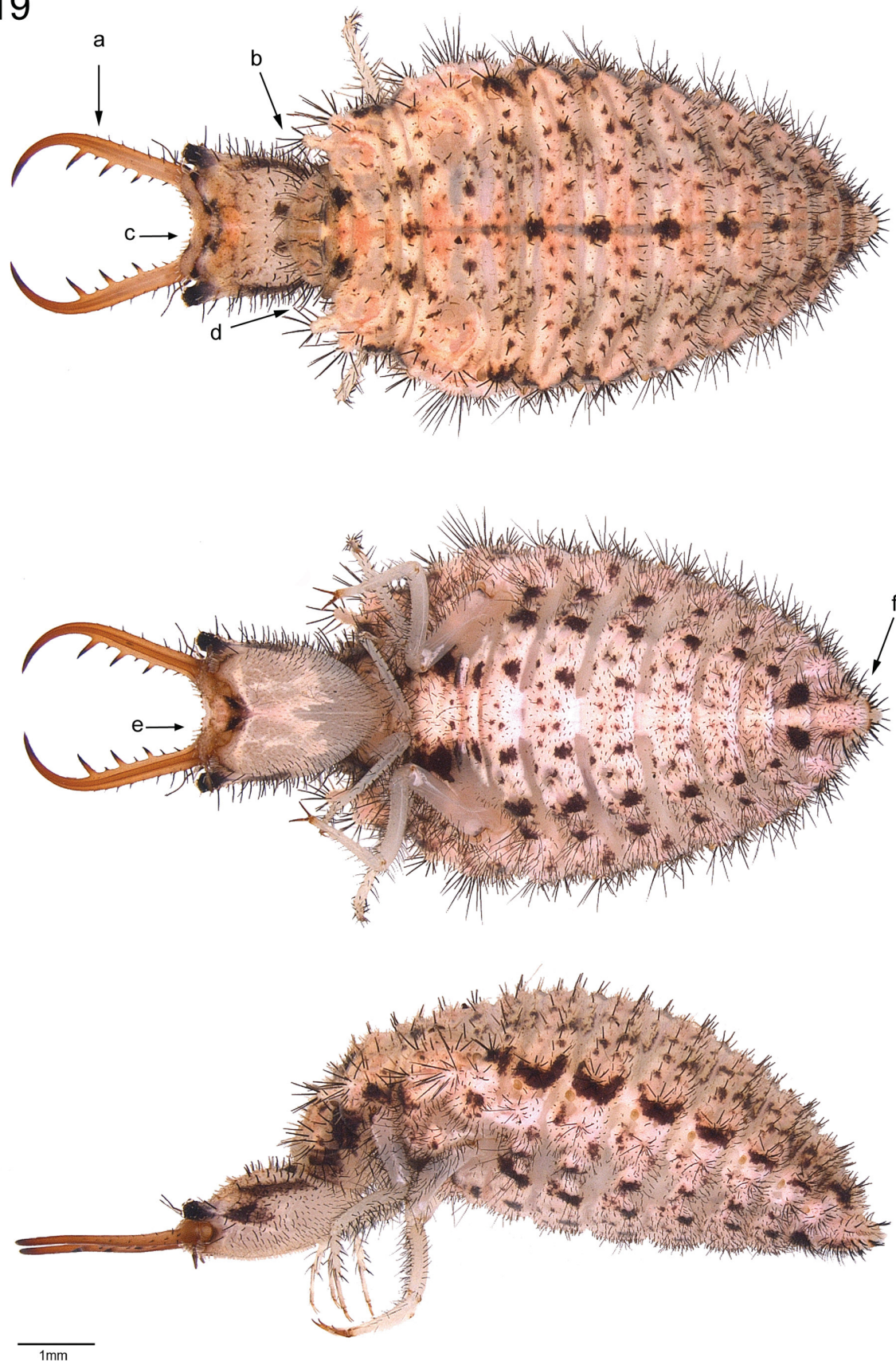
18



**FIGURE 18.** *Megistopus flavicornis* (Rossi, 1790), 3<sup>rd</sup> instar larva (Italy: Sardinia, Alghero). Dorsal (above), ventral (middle) and lateral (below) view; a–g: diagnostic characters, see species description. (photo by C. Cesaroni).



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**FIGURE 19.** *Megistopus lucasi* (Navás, 1912), 3<sup>rd</sup> instar larva (Italy: Sardinia, Chia). Dorsal (above), ventral (middle) and lateral (below) view; a–f: diagnostic characters, see species description.



protruding, not visible from above; VIII sternite without odontoid processes; IX sternite with a pair of dark markings on the side; rastra short and equipped with 4 digging setae, internal seta less than a quarter of the others in size (Figs. 3G, 19f).

**Bio-ecology.** *M. lucasi* is a poorly known species exclusively reported for coastal sites characterized by the presence of well preserved sand dunes. The larvae were collected in proximity of isolated junipers on open dunes, buried at the base of junipers and among their roots. In these conditions, the substratum is always composed by clean sand, without conspicuous quantities of organic debris except juniper needles. They are apparently absent from back dunes with a more thick vegetation.

**Distribution.** This very rare species is known for few coastal localities in Sardinia, Tyrrhenian Italy, Algeria and Tunisia.

**Remarks.** The larva of *M. lucasi* is characterized by an unmistakable habitus reminding *G. variegata*, despite the two species are easily set apart by the shape of the mandibles and the different hue of the body.

### ***Gymnocnemis* Schneider, 1845**

**Diagnosis.** Mandibles long and slender, equipped with 3 pairs of teeth, median and apical teeth subequal in size; pronotum covered by sparse dolichasters; mesothoracic spiracles raised on tubercle; thoracic setiferous processes pedunculated; VIII sternite with atrophied odontoid processes; IX sternite with rastra each bearing 4 digging setae of which the internal pair reduced.

**Examined species.** *G. variegata* (Schneider, 1845).

**Comments.** This genus comprises two species restricted to the western Palaearctic region and closely related to *Megistopus* (H. Aspöck *et al.* 2001; Stange 2004; Michel 2013).

### ***Gymnocnemis variegata* (Schneider, 1845)**

(Figs. 3H, 4H, 20)

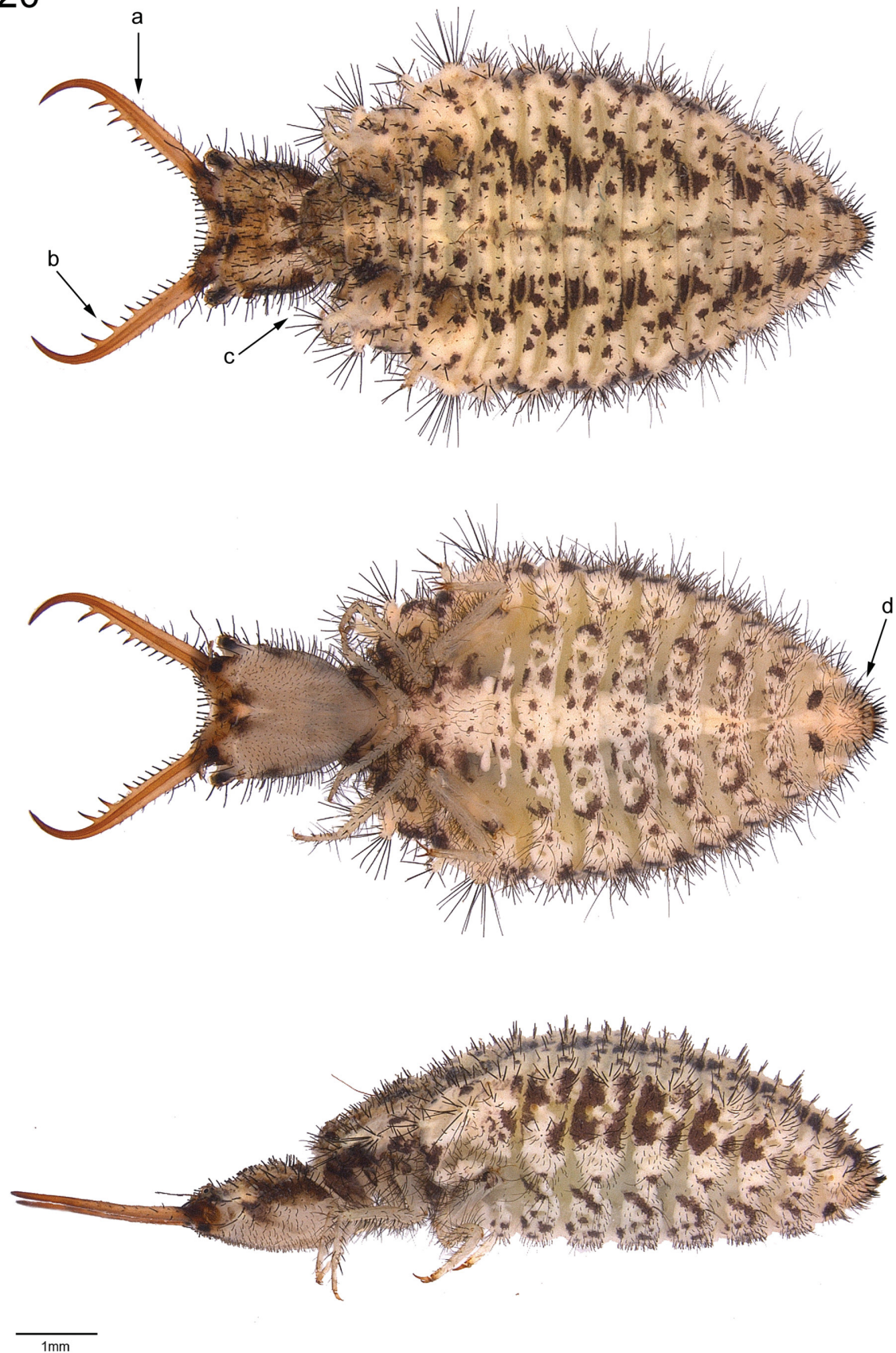
Willmann (1977) was the first to describe the larva of this species, wrongly but dubitatively identified as *Distoleon annulatus* since the older account of *G. variegata* by Hagen (1873) clearly refers to another antlion. Following mentions and illustrations (Insom *et al.* 1985; Stange & Miller 1990) are not exhaustive and the first adequate and comparative description is undoubtedly due to Cesaroni *et al.* (2010).

**Examined specimens. Italy.** Lazio, Roma, Monte Mario, bee-eater burrow on escarpment, VII.2010 (A. Alfonsi & C. Cesaroni), 4 L3; same locality, X.2011, 4 L3. **Greece.** Corfu, Panagias, rock escarpment in holm oak wood, V.2012 (D. Badano), 2 L3 and 2 L3 laboratory-reared to adult. Corfu, Lafki, V.2012, (D. Badano) 2 L3 laboratory-reared to adult, Corfu, Agios Markianos, rock escarpment in olive grove, VI.2012 (D. Badano), 1 L3. Corfu, Klimatia, V.2012 (D. Badano) 1 L3, laboratory-reared to adult. Corfu, Strynialas, V.2012 (D. Badano), 1 L3 laboratory-reared to adult

**Description of 3<sup>rd</sup> instar larva.** Size (based on 11 specimens): BL 7.41 mm; HL 2.07 mm (1.82–2.27), HW 1.71 mm (1.61–1.90), ML 2.20 mm (2.00–2.46), HW/HL 0.83, ML/HL 1.06. General colouring pale, yellowish brown with a brown pattern, ventrally paler; head capsule darker than the body, with large dark markings on the dorsal side, ventral side of the head unmarked, mandibles pale brown; legs pale; setae of the body black. Head longer than wide; mandibles thin, considerably longer than the head capsule (Fig. 20a); distance between the base of the mandible and basal tooth larger than that between the basal and the apical teeth (Fig. 20b); interdental mandibular setae: (6–7)(0–1)(0–1)(0); sparse setae are disposed on the external margin of the mandible. Pronotum covered by few sparse setae (Figs. 4H, 20c). Spiracles brown. VIII abdominal sternite provided with two well distinct dark spots; odontoid processes atrophied; IX sternite with rastra equipped with long and thin digging setae of which the internal pair is half the others in size (Figs. 3H, 20d).

**Bio-ecology.** *G. variegata* is found in Mediterranean environments such as woods and scrublands, however it is a relatively uncommon species and its presence is probably due to the strict microhabitat requirements of the larvae. The larvae are associated with rock escarpments, small caves and overhangs, especially on friable rocks or in presence of thick deposits of dry and fine detritus, where they are buried in cavities and crevices including abandoned burrows.

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**FIGURE 20.** *Gymnocnemia variegata* (Schneider, 1845), 3<sup>rd</sup> instar larva (Greece: Corfu, Panagias). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



**Distribution.** Widely distributed, but relatively rare, from the Mediterranean to Central Asia.

**Remarks.** The larva of this species is easily recognizable due to the long and thin mandibles and the body colouring.

### Tribe Myrmecaelurini Esben-Petersen, 1918

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule without prominent ocular tubercles; mandibles equipped with 3 teeth; median tooth longer than the other teeth; labial palpi four-articulated, segments 2–4 longer than the basal width of the mandible. Mesothoracic spiracles sessile. Thorax and abdomen with sessile setiferous processes. VIII abdominal sternite without odontoid processes, often equipped with digging setae; IX abdominal sternite wider than long, with prominent rastra.

**Biological notes.** This tribe includes both ambush hunters and pit-building species able to move both forward and backward.

**Comments.** Myrmecaelurini are characteristic of the steppes and deserts of the Palaearctic region while few species are reported for the Afrotropical region. The members of this tribe show a considerable variation in larval and adult characters therefore the internal relationships and with closely related tribes, such as Nesoleontini, need to be clarified.

### *Myrmecaelurus* A. Costa, 1855

**Diagnosis.** Mandibles with 3 teeth, the median tooth is the largest and closer to the apical tooth than to the basal tooth; the median and apical teeth are directly in contact and not separated by setae; external margin of the mandibles covered by long setae; ocular tubercle not prominent; pronotum covered with short and robust bristles; spiracles sessile; thorax equipped with sessile setiferous processes; metathoracic legs with a fringe of setae; VIII abdominal sternite without odontoid processes and provided with numerous digging setae; IX abdominal sternite ventrally covered by digging setae and equipped with very large rastra.

**Examined species.** *M. trigrammus* (Pallas, 1771).

**Comments.** The mainly Palaearctic genus *Myrmecaelurus* is not well delimited and it is often subdivided in different subgenera (Aspöck *et al.* 1980), in some case raised to genus level (Krivokhatsky 2011). The presence of notable morphological differences in the larvae belonging to *Aspoeckiana* Hölzel, 1969 and *Nohoveus* Navás, 1919 (Krivokhatsky 2011) further supports their status as separated genera.

### *Myrmecaelurus trigrammus* (Pallas, 1771)

(Figs. 1D, 2B, 21)

The first reliable larval description of this species was redacted by Redtenbacher (1883, 1884), because the previous accounts were not diagnostic and referable to other species (Brauer 1867; Hagen 1873). Curiously, in the past *M. trigrammus* was repeatedly described as the larva of other species of antlions: Redtenbacher (1883, 1884) erroneously assigned the larvae of this species also to *Creagris plumbeus*, *Macronemurus appendiculatus* and *Macronemurus bilineatus*; Doflein (1921), following the previous author, attributed them to *Macronemurus appendiculatus* and *Megistopus flavicornis*. Later Hölzel (1974) described the larva of this species mistaking it with *Myrmeleon gerlindae*. Recently the larva of this species was exhaustively treated (Willmann 1977; Popov 1984; Gepp 2010; Krivokhatsky 2011; Devetak *et al.* 2013).

**Examined specimens.** **Italy.** Calabria, Strogoli (Crotone), VIII.2010 (C. Labriola), 1 L3. Sicily, Gurne dell'Alcantara (Messina), VII.2010 (A. Corso), 3 L3. **Greece.** Rhodos, Kamiros, VII.2009 (D. Badano), 1 L3 laboratory-reared to adult. **Romania.** Dobruja, Badabag, VIII.2010 (C. Mancu), 2 L3. **Turkey.** Cappadocia, Göreme, V.2010 (A. Letardi), 3 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 9 specimens): BL 9.83 mm; HL 2.42 mm (2.29–2.59), HW 2.05 mm (1.97–2.18), ML 2.14 mm (1.78–2.32), HW/HL 0.85, ML/HL 0.88. General colouring ochre with dark

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**FIGURE 21.** *Myrmecaelurus trigrammus* (Pallas, 1771), 3<sup>rd</sup> instar larva (Italy: Calabria, Strogoli). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



brown markings, ventral side pale with dark spots; head capsule with dorsal and lateral sides dark brown while the area surrounding the ocelli is paler, ventral side of the head with a dark pattern (Fig. 21c); mandibles pale brown with a darker apex; setae of the body black. Head slightly longer than wide; mandibles shorter than the head capsule and comparatively robust; distance between the base of the mandible and basal tooth larger than that between the basal and the apical teeth, median tooth in contact with the apical tooth (Fig. 21a); interdental mandibular setae (+7)(2)(0)(0); external margin of the mandible with a fringe of long setae (Fig. 21b). Mesothoracic spiracles brown. Abdominal spiracles brown; VIII sternite with digging setae on the posterior margin; IX sternite with large digging setae, posterior margin with two prominent rastra bearing 4 subequal digging setae (Fig. 2B, 21d).

**Bio-ecology.** *M. trigrammus* is associated with steppe-like biotopes such as dry meadows and grasslands. The larvae are pit-builders but they also retain an ambush hunt behaviour that they display according to the situation. The pits are often built in open conditions, often in proximity tuft of grass, but they have also been observed near shelters such as stones, logs or rock escarpments.

**Remarks.** *M. trigrammus* is the only European member of the genus thus allowing to identify its larvae with ease. A similar species *M. major* McLachlan 1875 is reported from the uncertain border between Europe and Asia, however the larval stages of the latter remain unknown as well the other members of genus. The larvae of *Nohoveus zigan* H. Aspöck, U. Aspöck et Hölzel, 1980 and *Aspoeckiana uralensis* Hölzel, 1969 notably differ in the presence of setae between the median and apical mandibular teeth and in the characteristics of the IX sternite (Krivokhatsky 2011).

### Tribe Nesoleontini Markl, 1954

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule without prominent ocular tubercles; mandibles equipped with 3 teeth; median tooth longer than the other teeth; external margin of the mandible with long setae; labial palpi four-articulated, segments 2–4 longer than the basal width of the mandible. Mesothoracic spiracles raised on a very short tubercle. Thorax and abdomen provided with sessile setiferous processes. Metathoracic legs with a fringe of setae. VIII abdominal sternite with odontoid processes; IX abdominal sternite wider than long, with prominent rastra.

**Biological notes.** Pit-builder antlions also able to perform ambush hunting, they can move both forward and backward.

**Comments.** The tribe Nesoleontini comprises only 3 genera; two of them are limited to the Afrotropical region, while *Cueta* is widespread in the Old World (Stange 2004). The larvae are extremely similar to those of Myrmecaelurini, from which they differ only in small details, suggesting a close relationship between these two tribes set apart due to some adult characters, notably genitalia.

### *Cueta* Navás, 1911

**Diagnosis.** Anterior margin of the clypeo-labrum with a small median incision; mandibles with 3 teeth, the median tooth is the strongest and it is closer to the apical tooth than to the basal tooth; at least 1 seta is always present between the median and apical teeth; external margin of the mandibles provided with long setae; pronotum covered with short setae; mesothoracic spiracle raised on a very short tubercle, abdominal spiracles inconspicuous; thorax with sessile setiferous processes; metathoracic legs with a fringe of setae; VIII abdominal sternite with odontoid process and digging setae; IX sternite with an anterior group of two pairs of digging setae and two rastra each bearing 4 digging setae, one large digging seta is disposed at the base of each rastrum.

**Examined species.** *C. lineosa* (Rambur, 1842); *C. beieri* Hölzel, 1969.

**Comments.** The genus *Cueta* comprises at least 80 known species distributed in the arid areas of Eurasia and Africa (Stange 2004). The larvae are known only for a handful of species (Willmann 1977; Stange *et al.* 2003; Krivokhatsky 2011).

## Key to the European larvae of *Cueta*

- 1 Ventral side of the head with a pair of dark elongated markings; VIII abdominal sternite provided with broad and robust digging setae of which the median pairs are coupled on a common protuberance; odontoid processes very small (Figs. 2D, 23) . . . . . *C. lineosa*
- Ventral side of the head unmarked; VIII abdominal sternite provided with thin and bristle-like digging setae, without median pairs of digging setae raised on a protuberance, odontoid processes large (Figs. 2C, 22) . . . . . *C. beieri*

### *Cueta beieri* Hölzel, 1969

(Figs. 2C, 22)

The larva of this species was only described by Willmann (1977).

**Examined specimens. Greece.** Rhodos, Kamiros, VII.2009 (D. Badano), 1 L3 and 3 L3 laboratory-reared to adults; same locality XI.2010 (R. A. Pantaleoni), 4 L1 laboratory-reared to L3. Rhodos, Kiotari, XI.2010 (R. A. Pantaleoni), 2 L1 laboratory-reared to L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 7 specimens): BL 8.67 mm; HL 2.10 mm (1.81–2.25), HW 1.71 mm (1.56–1.81), ML 1.92 mm (1.67–2.09), HW/HL 0.81, ML/HL 0.91. General colouring pale brown with a dark pattern, ventral side whitish with contrasting dark markings; head capsule brown with a darker area in proximity of the clypeo-labrum, lateral sides of the head dark brown, ventral side of the head pale, unmarked (Fig. 22c); mandibles brown with a dark apex; legs pale; setae of the body black. Head longer than wide; mandibles comparatively robust, slightly shorter than the head capsule (Fig. 22b); median and apical teeth spaced by setae (Fig. 22a); interdental mandibular setae: (~5)(3)(1–2)(0). Mesothoracic spiracles on a short black tubercle. VIII abdominal sternite equipped with large odontoid processes, posterior margin covered by relatively thin bristle-like digging setae; IX sternite with two pairs of large and stout digging setae and two rastra each bearing 4 digging setae with a large seta at their base (Figs. 2C, 22d).

**Bio-ecology.** *C. beieri* live in open xeric biotopes such as grassland and low scrublands. The larvae dig their pit traps in exposed conditions in loose and dry soil, often near obstacles such as rocks and roots.

**Distribution.** Reported from Greece, Anatolia and Middle East.

**Remarks.** Following Krivokhatsky (2011), *C. beieri* Hölzel, 1969 is a junior synonym of *C. anomala* Navás, 1915. Further studies are needed to verify this statement, *C. anomala* was described from only one female collected in an undetermined locality of “Persia” and the diagnostic characters of the female of *Cueta* are of uncertain value. Therefore the synonymy of *C. albanica* Capra, 1945 (known from a single female) with *C. anomala*, as suggested by Krivokhatsky (2011), is also doubtful. Consequently, despite the proposed synonymies appear justifiable, the name *C. beieri* is retained here.

### *Cueta lineosa* (Rambur, 1842)

(Figs. 2D, 23)

The larvae are insufficiently known. Lackinger (1973) simply compared the proportions of head of this species with *M. trigrammus*, while the description of Mirmoayedi (2002) is excessively concise, even insufficient to discriminate it from other antlions.

**Examined specimens. Greece.** Rhodos, Vati, grassland, VII.2009 (D. Badano), 1 L3. Rhodos, Tsambika, back dune, VII.2009 (D. Badano), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 2 specimens): BL 8.75 mm; HL 1.85 mm (1.82–1.87), HW (1.37–1.45), ML 1.70 mm (1.67–1.72), HW/HL 0.76, ML/HL 0.92. General colouring light brown with brown pattern, ventral side pale ochre with contrasting dark markings; head capsule dark brown with a paler V-shaped anterior marking and a median pale stripe, lateral side with extensive markings, ventral side of the head paler with a distinctive median pair of elongated markings (Fig. 23c); mandibles pale brown, darker toward the tip; legs pale; setae of the body black. Head longer than wide, relatively small in comparison to the body; mandibles almost as long as the head capsule; median and apical teeth spaced by setae (Fig. 23a); interdental mandibular setae (~8)(2–3)(1)(1 very small); dorsal side of the mandibles covered by few short setae, ventral side with sparse and short



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**FIGURE 22.** *Cueta beieri* Hölzel, 1969, 3<sup>rd</sup> instar larva (Greece: Rhodos, Kiotari). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.

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**FIGURE 23.** *Cueta lineosa* (Rambur, 1842), 3<sup>rd</sup> instar larva (Greece: Rhodos, Tsambika). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



setae, lateral side with a fringe of setae (Fig. 23b). Mesothoracic spiracles dark brown. VIII sternite provided with very small odontoid processes, posterior margin equipped with large and stout digging setae, the internal pairs are the largest and grouped on protuberances; IX sternite with two pairs of stout digging setae and two rastra each bearing 4 digging setae with a large seta at their base (Figs. 2D, 23d).

**Bio-ecology.** *C. lineosa* is associated with open and arid environments such as scrublands, steppes or even deserts. The larvae were collected in back dunes with sparse vegetation and in dry grasslands.

**Distribution.** Widespread in arid areas of North Africa and Eurasia.

**Remarks.** The larva of *C. lineosa* is notable for the presence in the mandibles of 1 seta, though very short and easily overlooked, after the apical tooth; this character is normally typical of the tribe Myrmeleontini.

### Tribe Acanthaclisini Navás, 1912

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule without prominent ocular tubercles; mandibles equipped from one to three teeth; labial palpi four-articulated, segments 2–4 shorter than the basal width of the mandible. Mesothoracic spiracles sessile. Thorax and abdomen with sessile setiferous processes. Legs with a fringe of setae. VIII abdominal sternite without odontoid processes; IX abdominal sternite bearing digging setae but without rastra.

**Biological notes.** The larvae of this tribe are not pit-building antlions able to move both forward and backward; some genera are characterized by the ability to move only backward.

**Comments.** This distinctive and widespread tribe is comparatively the better known one in the family regarding the larval stages, thanks to the review of Stange & Miller (1985).

### *Acanthaclisis* Rambur, 1842

**Diagnosis.** Anterior margin of the clypeo-labrum with a median cuneiform process; mandibles swollen basally, equipped with 3 teeth of which the median tooth is slightly longer than the others; ventral portion of the head capsule with sparse setae; pronotum thickly covered by stout setae; thorax with sessile setiferous processes; VIII sternite with digging setae; IX sternite with digging setae.

**Examined species.** *A. occitanica* (Villers, 1789).

**Comments.** *Acanthaclisis* is a Palaearctic genus including 7 species. The larvae have been exclusively described for *A. occitanica* and *A. pallida* (McLachlan, 1887) (Brauer 1855b; Luppova 1969; Steffan 1975; Krivokhatsky 2011).

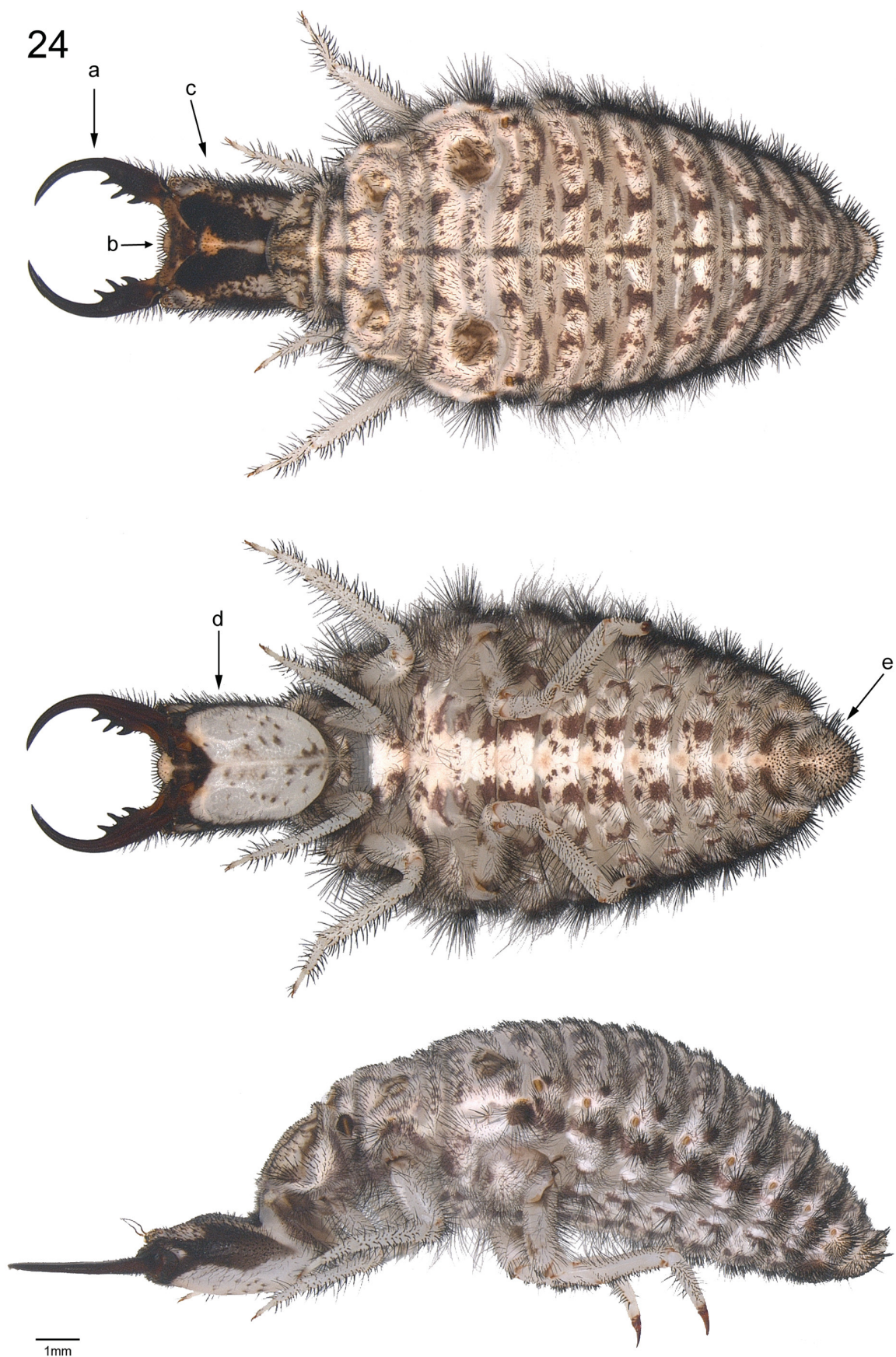
### *Acanthaclisis occitanica* (Villers, 1789)

(Figs. 2E, 24)

The larva of this species was described for the first time in a pioneering work by Percheron (1833) as *Myrmeleon libelluloides*. However, the first rigorous account was later redacted by Brauer (1855b), also detailing its ecology and behaviour (Brauer 1855b). This large species was treated many times (Hagen 1873; Redtenbacher 1884; Steffan 1975; Willmann 1977; Gepp & Hölzel 1989; Gepp 2010; Krivokhatsky 2011). In the XIX century the larva of this antlion was repeatedly confused with *Synclisis baetica*, much more easier to find in the field (Dufour 1854; Ferrari 1864; Girard 1875; Dubois 1899).

**Examined specimens.** **Portugal.** Estremadura, San Martinino, VII.1996 (A. Molinu), 2 L3. **Italy.** Sardinia, Alghero (Sassari), Maria Pia, back dunes, IV.2008 (C. Cesaroni), 1 L3; same locality, XI.2009 (D. Badano), 1 L2. Sardinia, Spiaggia del Liscia (Nuoro), IX.2009 (L. Lenzini), 3 L3. Sardinia, Sa Tiria Posada (Nuoro), V.2006 (R. A. Pantaleoni), 1 L2. Sardinia, Scivu, Arbus, back dune (Oristano), V.2010 (D. Badano), 1 L2.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 6 specimens): BL 23.37 mm; HL 4.58 mm (4.43–4.89), HW 3.75 mm (3.69–3.92), ML 3.55 mm (3.42–3.72), HW/HL 0.82, ML/HL 0.78. General colouring grey with a dark pattern, ventral side pale with dark spots; head capsule with conspicuous dark markings on the dorsal and lateral sides (Fig. 24c), ventral side of the head pale with a dark area covering the mouthparts and isolated spots at the



**FIGURE 24.** *Acanthaclisis occitanica* (Villers, 1789), 3<sup>rd</sup> instar larva (Italy: Sardinia, Spiaggia del Liscia). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description. (photo by C. Cesaroni).



insertion of ventral setae (Fig. 24d); mandibles completely black; legs pale; setae of the body black. Head rectangular, a little longer than wide; anterior margin of the labrum with a cuneiform process bearing setae on the external margin (Fig. 24b); mandibles very strong, shorter than the head capsule, noticeably broader in correspondence of basal tooth, apical tooth at a different angle than the other teeth (Fig. 24a); interdental mandibular setae: (~2)(1)(1)(0); external margin of the mandibles covered by bristle in the basal half. Mesothoracic spiracles dark. Abdominal spiracles dark; VIII sternite with ventral stout digging setae; IX sternite rounded in shape, equipped with robust digging setae similar to those disposed on the previous sternite (Figs 2E, 24e).

**Bio-ecology.** The larvae of *A. occitanica* are typical inhabitants of back dunes with a relatively complex vegetation, characterized by the presence of bushes or trees, where the sand is rich in organic debris acquiring a dark colour. Nevertheless this antlion is also found in sandy habitats far from the coast such as fluvial deposits, steppes and relict dunes. The larvae are often hidden among roots, near tree bases or under shrubs.

**Distribution.** Widespread in the western Palaearctic. This species was notably reported from coastal sites on the North and Baltic seas, where it is now extinct (Brauer 1855b).

**Remarks.** *A. occitanica* is the only member of the genus in western Europe while in Russia it is also present the closely related *A. pallida*, whose larva was described by Luppova (1969); according to this account, the larvae of the two species apparently differ only in the colour of the mandibles.

### *Synclisis* Navás, 1919

**Diagnosis.** Mandibles with 3 equidistant teeth, the apical tooth is the largest; no setae between the base of the mandible and basal tooth; thorax covered by short setae; thorax with sessile setiferous processes; legs with a fringe of setae on the posterior side of the tibia, particularly evident in the metathoracic leg; VIII abdominal sternite without digging setae; IX abdominal sternite triangular in shape with a median series of digging setae.

**Examined species.** *S. baetica* (Rambur, 1842).

**Comments.** The genus *Synclisis* comprises 3 Palaearctic species of which only *S. baetica* belongs to the European fauna; a fourth species from Madagascar is considered of doubtful taxonomic placement (Stange 2004). The larvae have been described for *S. baetica* and *S. kawaii* (Nakahara, 1913) (Principi 1947; Stange & Miller 1985; Stange *et al.* 2003).

### *Synclisis baetica* (Rambur, 1842)

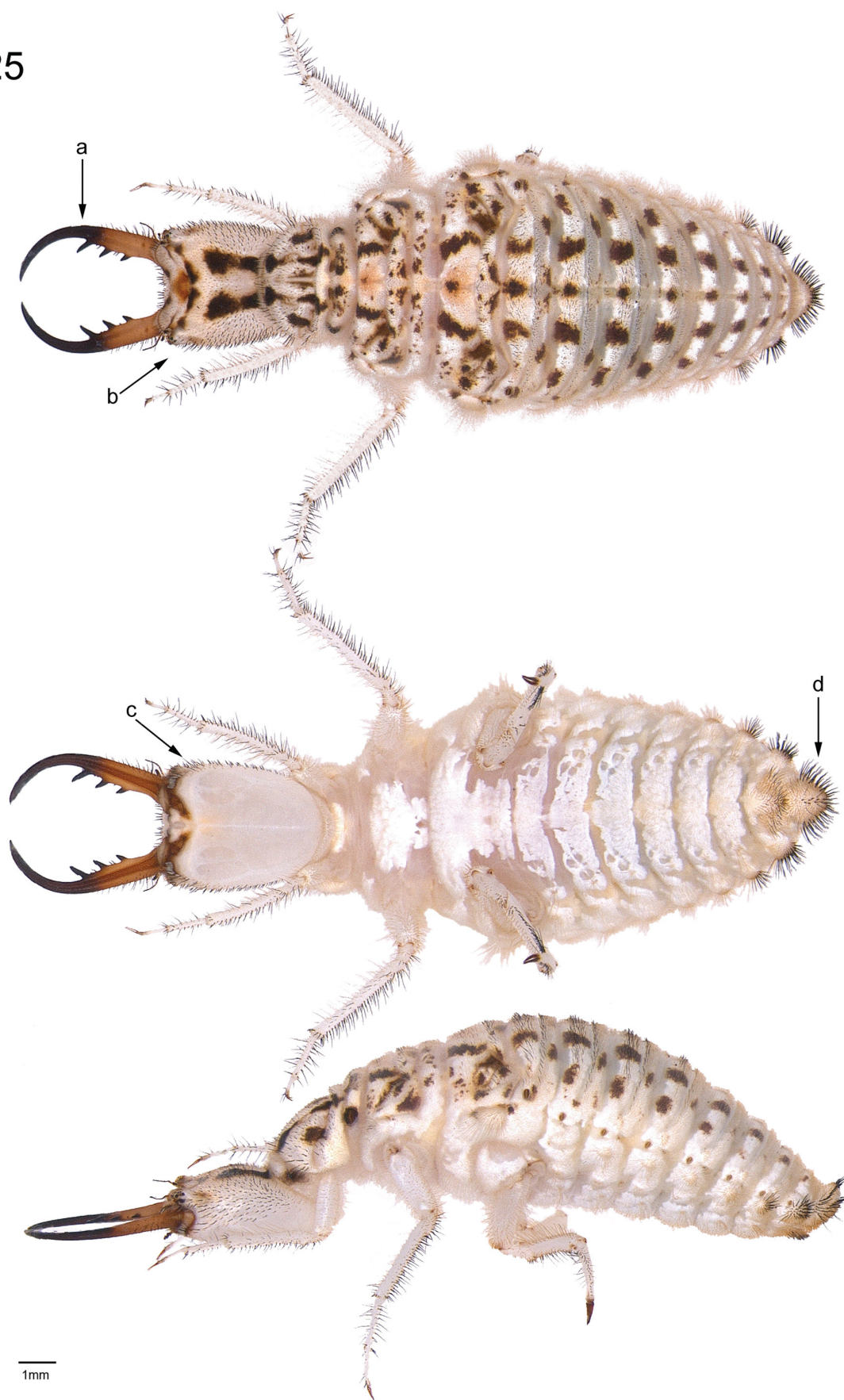
(Figs. 2F, 25)

The remarkable larva of this species has a surprisingly long history of misidentifications with *A. occitanica* (Dufour 1854; Ferrari 1864; Girard 1875; Dubois 1899) and even with *Palpares* (McLachlan 1873; Navás 1923). The first description with correct identification was realized by Redtenbacher (1884), followed few years later by an anatomic study by Meinert (1889) despite the latter author identified this species as “*Myrmeleon pallidipennis* Rambur?”. The best study on the biology of this species is the excellent work of Principi (1947) dealing the life cycle, the larval morphology, ecology and behaviour. This antlion is probably the better known European non pit-building species being extensively studied (Richard 1952; Richard & Pons 1952; Saffré 1957; Steffan 1975; Stange & Miller 1985; Gepp & Hölzel 1989; Gepp 2010; Krivokhatsky 2011).

**Examined specimens. Italy.** Lazio, Sabaudia (Latina), V.2006 (R. A. Pantaleoni), 1 L3. Sardinia, Sassari (Sassari), Porto Ferro, coastal dune, V.1999 (R. A. Pantaleoni), 2 L3; same locality VII.1999 (R. A. Pantaleoni), 2 L2. Sardinia, Sorso (Sassari), Platamona, coastal dune, V.1994 (R. A. Pantaleoni), 1 L1 and 4 L2; same locality IV.1999 (C. Cesaroni), 1 L3; same locality IX.2010 (D. Badano), 1 L3; same locality VIII.2012 (D. Badano), 1 L3. Sardinia, Alghero (Sassari), Maria Pia, coastal dune, V.1992 (R. A. Pantaleoni), 1 L3; XI.2009 (D. Badano), 2 L3. Sardinia, Arbus (Oristano), Torre dei Corsari, coastal dune, IV.2011 (D. Badano), 1 L3. **Tunisia.** Tunis, Plage Rafrat VI.2006 (R. A. Pantaleoni), 1 L3. Zairaâ beach, VI.2006 (R. A. Pantaleoni), 1 L2 and 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 12 specimens): BL 19.60 mm; HL 4.55 mm (4.09–5.00), HW 3.62 mm (3.10–4.27), ML 3.55 mm (3.51–4.42), HW/HL 0.80, ML/HL 0.78. General colouring very pale, sand-like with a conflicting black pattern on the dorsal side, ventral side whitish, unmarked; head capsule with a dorsal

25



**FIGURE 25.** *Synclisis baetica* (Rambur, 1842), 3<sup>rd</sup> instar larva (Italy: Sardinia, Sorso, Platamona). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



pair of large dark markings (Fig. 25b), lateral and ventral sides unmarked (Fig. 25c); mandibles light brown with a dark apex; legs pale; body covered by both black and robust setae and by whitish hair-like ones. Head rectangular, longer than wide; mandibles strong, slightly shorter than the head capsule (Fig. 25a); interdental mandibular setae: (0)(1–2)(1–2)(0); short setae are disposed on the external margin of the mandibles from the base to the apical tooth. Mesothoracic and abdominal spiracles dark. VIII abdominal sternite covered by large setae, thicker in proximity of the distal margin; IX sternite triangular in shape, with a transversal series of dark digging setae, caudal margin provided with large setae (Figs. 2F, 25d).

**Bio-ecology.** *S. baetica* is strictly associated with extensive sandy biotopes with limited vegetal covering, therefore it is a characteristic element of open coastal sand dunes although also reported from internal sandy habitats. It is a particularly common species in relatively undisturbed coastal dunes of the Mediterranean. The larvae of *S. baetica* are often buried at the base of psammophilus plants, where they are protected from atmospheric agents. The larvae are aggressive and active predators, able to rapidly pursue the prey for a short distance; during the day they are hidden under the sand surface, ambush hunting, while during the night they roam freely on the dunes.

**Distribution.** A widespread species in the western Palaearctic.

**Remarks.** Highly unmistakable larva without closely related species in the western Palaearctic.

### Tribe Myrmeleontini Latreille, 1802

**Diagnosis of 3<sup>rd</sup> instar larva.** Head capsule without prominent ocular tubercles; mandibles equipped with three pairs of parallel teeth; external margin of the mandible provided with long setae; apical tooth longer than the median tooth; labial palpi commonly four-articulated (three-articulated in some species), segments 2–4 shorter than the basal width of the mandible. Mesothoracic spiracles not raised on tubercle, abdominal spiracles inconspicuous. Thorax and abdomen equipped with sessile setiferous processes. Metathoracic legs with a fringe of setae; VIII abdominal sternite with odontoid processes; IX with rastra and specialized digging setae.

**Biological notes.** Obligate pit-builders able to move only backward.

**Comments.** This large and widespread tribe comprises the most common pit-builder antlions. The larvae of most genera are known, appearing noticeably uniform in overall morphology (Stange 2004).

### *Myrmeleon* Linnaeus, 1767

**Diagnosis.** Anterior margin of the clypeo-labrum slightly concave; mandibles with 3 equidistant teeth of which the apical one is the strongest, although only slightly, 1 seta is always present after the apical tooth, external margin of the mandibles provided with long setae; labial palpi normally four-articulated (with few exceptions); pronotum covered by short stout setae; meso- and metathorax with sessile setiferous processes; VIII abdominal sternite provided with odontoid processes (slightly pronounced in some species) and with spiniform or stout setae on the posterior margin; IX abdominal sternite at least with an anterior row group of digging setae and two short rastra each bearing 4 digging setae, some species are provided with additional ventral digging setae.

**Examined species.** *M. formicarius* Linnaeus, 1767; *M. gerlindae* Hölzel, 1974; *M. punicanus* Pantaleoni & Badano, 2012; *M. bore* (Tjeder, 1941); *M. inconspicuus* Rambur, 1842; *M. mariaemathildae* Pantaleoni, Cesaroni & Nicoli Aldini, 2010; *M. hyalinus* Olivier, 1811; *M. fasciatus* (Navás, 1914).

**Comments.** This cosmopolite genus is the most speciose in the whole family, comprising about 180 species (Stange 2004), despite the reciprocal relationships among species and closely related genera are unclear. The larvae of a notable number of species have been described, resulting the better known genus in this respect (Stange 2004), although the state of knowledge regarding the ecological requirements and morphology of most species is very inadequate, especially for tropical ones. The larvae of most European species have been described (see text).

## Key to the known larvae of European *Myrmeleon*

- 1 Labial palpi 3-articulated (Fig. 5D). . . . . *M. bore*
- Labial palpi 4-articulated (Fig. 5E). . . . . 2
- 2 IX abdominal sternite with anterior row of digging setae composed by 4 setae (Figs. 6A, 6G) . . . . . 3
- IX abdominal sternite with anterior row of digging setae composed by at least 6 (exceptionally 5) setae (Figs. 6E, 6F). . . . . 4
- 3 Coxae of the hind pair of legs with large dark markings (Figs. 26–28) . . . . . 4
- Coxae of the hind pair of legs without markings (Figs. 32, 33) . . . . . 6
- 4 Ventral side of the mandible with a covering of setae external to the maxilla reaching the basal tooth; femora of the hind pair of legs spotless (Fig. 27) . . . . . *M. gerlindae*
- Ventral side of the mandible with a covering of setae external to the maxilla reaching the middle tooth; femora of the hind pair of legs spotted (Figs. 26, 28). . . . . 5
- 5 Small larva, head capsule length less than 2 mm, mesothoracic coxae unspotted (Fig. 28). . . . . *M. punicanus*
- Large larva, head capsule length more than 2 mm, mesothoracic coxae spotted (Fig. 26). . . . . *M. formicarius*
- 6 Ventral side of the head with a pair of dark elongated markings; ventral side of the mandible with a very sparse covering of setae external to the maxilla; body with a recognizable dark pattern (Fig. 32) . . . . . *M. hyalinus*
- Ventral side of the head without markings; ventral side of the mandible with a thick covering of setae external to the maxilla; body without contrasted dark areas (Fig. 33) . . . . . *M. fasciatus*
- 7 Dark habitus; IX abdominal sternite with the anterior row of digging setae composed by equal-sized setae (Figs. 6E, 30). . . . . *M. inconspicuus*
- Pale habitus; IX abdominal sternite with the anterior row of digging setae composed by large setae disorderly interspersed with shorter ones (Figs. 6F, 31). . . . . *M. mariaemathildae*

### *Myrmeleon formicarius* Linnaeus, 1767

(Figs. 5A, 6A, 26)

Linnaeus (1745, 1758) attributed to this species some larvae that he observed in Öland (Sweden), nevertheless the larva of this antlion was described for the first time more than a century later by Brauer (1853) as *M. formicalynx* (see also under *E. nostras*). The larva of *M. formicarius* is one of the best known in the family and it was treated in numerous studies (Hagen 1873; Redtenbacher 1883, 1884; Doflein 1916; Eglin 1940; Friheden 1973; Steffan 1975; Matura 1987; Eisenbeis & Wichard 1987; Gepp & Hölzel 1989; Gepp 2010; Krivokhatsky 2011).

**Examined specimens. Portugal.** Parque Nacional da Penada, VII.2011 (B. Michel), 2 L3. **Italy.** Val d'Aosta, Aymavilles (Aosta), Pont d'Ael, under rock overhang, VIII.2012 (D. Badano), 4 L3. Piedmont, Torino (Torino), VII.2010 (A. Alma), 4 L3. Tuscany, Follonica (Grosseto), VII.2010 (M. Bastianini), 2 L3. Tuscany, Montieri (Grosseto), VII.2010 (M. Bastianini), 2 L3. Tuscany, Casale Marittimo (Pisa), VII.2010 (M. Bastianini), 4 L3. Lazio, Roma (Roma), Prataglia di Cervara, VI.2010 (M. Gigli), 2 L3. Sicily, Mt. Etna, VII.2010 (F. Camino), 1 L3. **Romania.** Dobruja, Badabag, VIII.2010 (C. Mancini), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 22 specimens): BL 9.11 mm; HL 2.28 mm (2.11–2.55), HW 2.04 mm (1.80–2.42), ML 2.41 mm (2.14–2.70), HW/HL 0.89, ML/HL 1.06. General colouring dark brown with a dark pattern, ventral side pale with dark spots; dorsal side of the head capsule with large paired markings, lateral side of the head with large dark markings, ventral side mottled with dark brown with a pair of large spots (Figs. 5A, 26c), mandibles pale brown; legs pale, metathoracic pair of legs with dark spots on the coxae and femora (Fig. 26d); setae of the body black. Head slightly longer than wide; mandibles relatively robust, as long as the head capsule (Fig. 26a); interdental mandibular setae: (+6)(2–3)(2–3)(1); dorsal side of the mandible covered by sparse, short setae, ventral side with a thick covering of short setae external to the maxilla, reaching the median tooth and very few setae internal to the maxilla (Figs. 5A, 26b). IX abdominal sternite with an anterior row of digging setae composed by 4 setae divided in 2 groups and with two sessile rastra each bearing 4 digging setae (Figs. 6A, 26e).

**Bio-ecology.** *M. formicarius* is one of the commonest European species despite in southern Europe it is limited to mountainous habitats or to suitable fresh lowland biotopes, avoiding warm and arid sites. This species prefers habitats characterized by the presence of arboreal vegetation and of loose dry substratum. The larvae build their pits both in exposed and sheltered conditions such as under tuft of plants, rock overhangs or in proximity of small escarpments.

**Distribution.** Widespread Palearctic species.





**FIGURE 26.** *Myrmeleon formicarius* Linnaeus, 1767, 3<sup>rd</sup> instar larva (Italy: Lazio, Roma, Prataglia di Cervara). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.

**Remarks.** The larva of *M. formicarius* is the only species in central and northern Europe with spotted metathoracic legs. The 3<sup>rd</sup> instar larva is also recognizable due to the large dimensions, being the largest European member of the tribe.

### ***Myrmeleon gerlindae* Hölzel, 1974**

(Figs. 5B, 6B, 27)

The larva of this species is described for the first time, as the account by Hölzel (1974) actually refers to *Myrmecaelurus trigrammus*.

**Examined specimens. Italy.** Liguria, Bordighera (Imperia), Monte Nero, scrubland, VIII.2010 (D. Badano), 3 L3. Sardinia, Alghero (Sassari), Capocaccia, coastal juniper thicket, VI.2010, 1 L3 and 1 L3 laboratory-reared to adult; same locality, V.2012 (D. Badano), 11 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 15 specimens): BL 7.68 mm; HL 1.85 mm (1.58–2.00), HW 1.60 mm (1.44–1.73), ML 1.77 mm (1.62–1.92), HW/HL 0.86, ML/HL 0.96. General colouring dark brown with darker markings, ventrally paler with large dark areas; dorsal side of the head capsule with a pair of dark markings, lateral side of the head with large dark markings, ventral side of the head with an anterior pair of dark markings surrounding the gula and two median dark spots (Figs. 5B, 27c); mandibles pale brown; pro- and mesothoracic pair of legs pale, metathoracic legs with spotted coxae but unmarked femora (Fig. 27d); setae of the body black. Head slightly longer than wide; mandibles as long as the head capsule (Fig. 27a); interdental mandibular setae: (+6)(2–3)(2–3)(1), dorsal side of the mandible covered by sparse short setae, ventral side with a sparse covering of short setae external to the maxilla, reaching the basal tooth and few isolated setae (or no one) disposed internal to the maxilla (Figs. 5B, 27b). IX abdominal sternite with an anterior row of digging setae composed by 4 setae divided in 2 groups and with two sessile rastra each bearing 4 digging setae (Figs. 6B, 27e).

**Bio-ecology.** This poorly known antlion is apparently an ecological vicariant of the closely related *M. formicarius*, replacing the latter in xeric biotopes. *M. gerlindae* is associated with arid woods and scrublands. The larvae build their pits in sheltered sites such as at the base of trees, under bushes or rock overhangs.

**Distribution.** *M. gerlindae* is a typical W-Mediterranean faunal element, reported for Morocco, Iberian Peninsula, southern France, Sardinia and western Liguria (north-west Italy).

**Remarks.** Mainly recognizable due to the pigmentation of legs.

### ***Myrmelon punicanus* Pantaleoni & Badano, 2012**

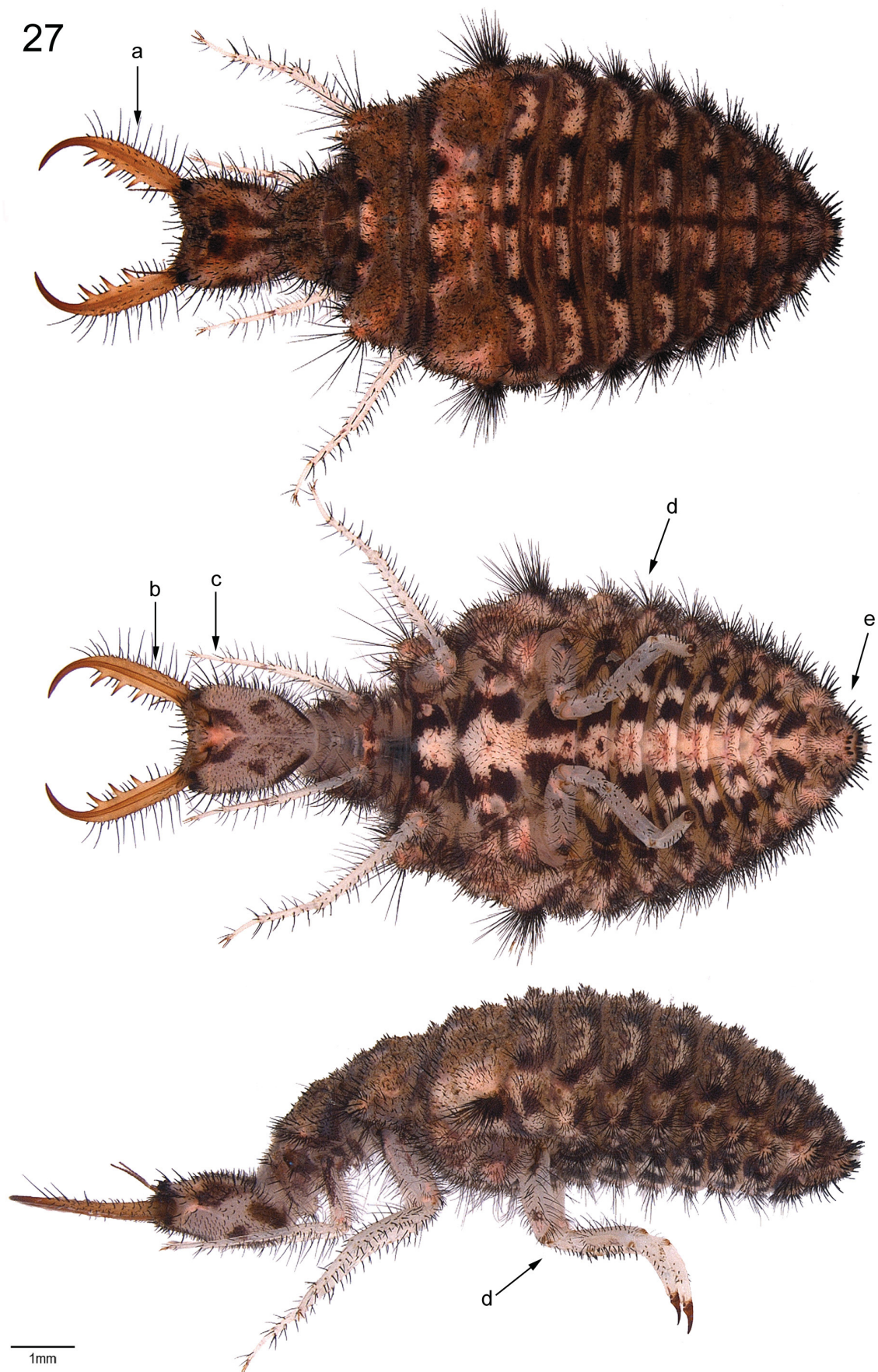
(Figs. 5C, 6C, 28)

A recently described species (Pantaleoni & Badano 2012) whose larva has not been compared with other congeners.

**Examined specimens. Italy.** Sicily, Mazara del Vallo (Trapani), Gorgi Tondi, IX.2011 (M. Romano), 3 L3. Pantelleria (Trapani), Bugeber, V.2010 (A. Corso), 3 L3.

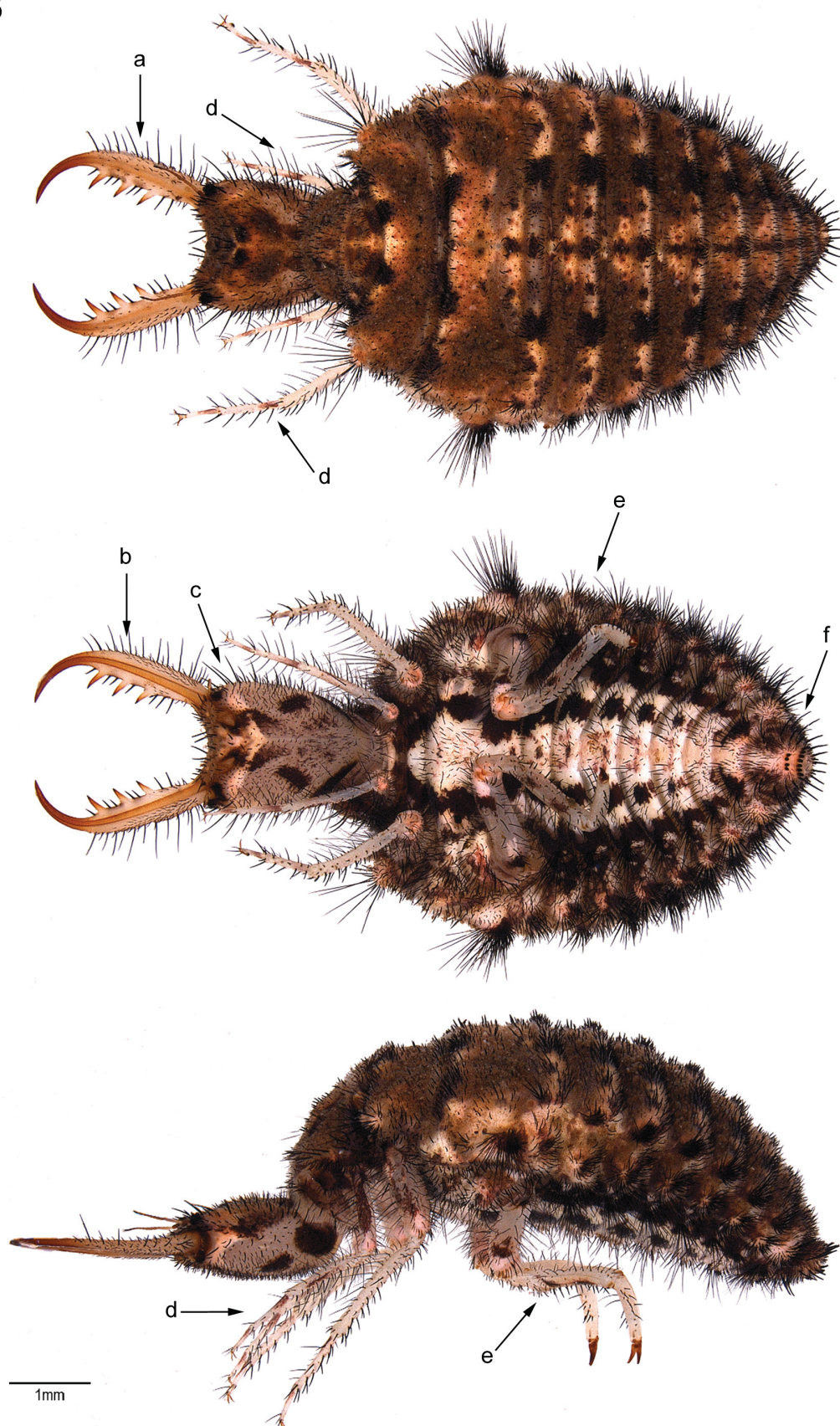
**Description of 3<sup>rd</sup> instar larva.** Size (based on 6 specimens): BL 8.57 mm; HL 1.93 mm (1.84–2.03), HW 1.64 mm (1.56–1.75), ML 1.90 mm (1.86–1.93), HW/HL 0.85, ML/HL 0.98. General colouring dark brown with a dark pattern, ventral side pale with large dark spots; dorsal side of the head capsule brown with small dark markings, lateral side of the head with large dark markings, ventral side of the head paler with an anterior pair of dark markings surrounding the gula and a two median dark spots (Figs. 5C, 28c); mandibles pale brown; pro- and mesothoracic pair of legs pale with darker suffusions at the proximal section of the tibiae and of the tarsi (Fig. 28d), metathoracic pair of legs pale with conspicuous dark spots on the coxae and on the femora (Fig. 28e); setae covering the body black. Head longer than wide; mandibles as long as the head capsule (Fig. 28a); interdental mandibular setae: (2–4)(2)(2)(1); dorsal side of the jaws covered by sparse and short setae, ventral side with a thick covering of short setae external to the maxilla, reaching the median tooth, few setae disposed internal to the maxilla, reaching the basal tooth (Figs. 5C, 28b). IX abdominal sternite equipped with an anterior row of digging setae and with two sessile rastra each bearing 4 digging setae (Figs. 6C, 28f).





**FIGURE 27.** *Myrmeleon gerlindae* Hölzel, 1974, 3<sup>rd</sup> instar larva (Italy: Sardinia, Alghero, Capo Caccia). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.





**FIGURE 28.** *Myrmeleon punicanus* Pantaleoni & Badano, 2012, 3<sup>rd</sup> instar larva (Italy: Pantelleria, Bugeber). Dorsal (above), ventral (middle) and lateral (below) view; a–f: diagnostic characters, see species description.



**Bio-ecology.** *M. punicanus* is a pit-builder species associated with Mediterranean forest environments. The larvae were collected in scrublands in small patches of loose soil, under the shelter of rock overhangs and vegetation.

**Distribution.** Exclusively reported for Sicily and Pantelleria.

**Remarks.** The larva of *M. punicanus* reminds a miniature version of *M. formicarius*, however it is distinguished by the dark soffusions at the articulations of the legs.

### ***Myrmeleon bore* (Tjeder, 1941)**

(Figs. 5D, 6D, 29)

The first observations of the larva of this antlion predate the species description (Schenck 1877; Dewitz 1882) while the first actual description dates back to almost a century later (Friheden 1973). It was redescribed by Matsura (1987) and Nicoli Aldini (2007), who compared it with closely related species. This species is finally treated in some monographic volumes (Gepp & Hölzel 1989; Gepp 2010; Krivokhatsky 2011).

**Examined specimens. Germany.** Mecklenburg Vorpommern, Graal Müritz, VI.2011 (C. Kehlmaier), 3 L3. **Italy.** Lombardy, Pieve Albignola (Pavia), Cascinotto Mensa, IX.1979 (R. Nicoli Aldini), 2 L3. Lombardy, Casterno (Milano), Ticino River, V.2012 (D. Piccolino), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 6 specimens): BL 8.31 mm; HL 2.06 mm (1.90–2.20), HW 1.74 mm (1.61–1.84), ML 2.25 mm (2.13–2.34), HW/HL 0.84, ML/HL 1.09. General colouring pale brown mottled with dark brown, ventrally very pale with dark brown spots; dorsal side of the head capsule with large markings on the clypeo-labrum and posterior V-shaped marking, lateral sides of the head with dark markings, ventral side of the head pale with a pair of median dark spots (Figs. 5D, 29c); mandibles pale brown with a dark apex; legs pale; setae of the body black. Head longer than wide; mandibles slightly longer than the head capsule (Fig. 29a); interdental mandibular setae: (~5)(2–3)(2–3)(1); ventral side of the mandible with few setae at the base; labial palpi 3-articulated (Figs. 5D, 29b). IX abdominal sternite with sparse ventral digging setae, followed by an anterior row of digging setae and two sessile rastra each bearing 4 bristles (Figs. 6D, 29d).

**Bio-ecology.** *M. bore* lives in fresh environments and it is absent from areas influenced by a Mediterranean climate. *M. bore* is associated with sandy biotopes such as coastal dunes, river banks and internal sand deposits. The pits are built in exposed conditions, although the first stages are often found in proximity of vegetation.

**Distribution.** Widespread in the Palaearctic, from western Europe eastward to Japan.

**Remarks.** The larva of *M. bore* is the only known European antlion with 3 palpomeres. This species is similar to *M. inconspicuus* and to the non sympatric *M. mariaemathildae* in overall morphology; it is differentiated by the larger dimensions and the relative proportions of the mandibles and the head capsule.

### ***Myrmeleon inconspicuus* Rambur, 1842**

(Figs. 5E, 6E, 30)

The larva of this species was described for the first time by Redtenbacher (1883, 1884), as *Myrmeleon erberi* Brauer, 1868. The better existing description of this antlion is undoubtedly the masterly study of Principi (1943), detailing its morphology, ecology and behaviour. The larva of *M. inconspicuus* has been redescribed in several occasions mainly for identification purposes (Steffan 1975; Hölzel & Gepp 1989; Nicoli Aldini 2007; Gepp 2010; Krivokhatsky 2011).

**Examined specimens. Italy.** Val d'Aosta, Aymavilles (Aosta), Pont d'Ael, rock overhang, VIII.2011 (D. Badano), 1 L3 laboratory-reared to adult. Veneto, Venezia (Venezia), Punta Sabbioni, III.2012 (E. Ruzzier), 7 L3. Campania, Castelvita (Salerno), Calore River, VII.2010 (C. Labriola), 2 L3. Sardinia, Alghero (SS), Porticciolo, sand beach, III.2010 (D. Badano), 1 L3. Sardinia, Alghero (Sassari), Lazzaretto, sand beach, X.2010 (D. Badano), 1 L3; same locality, III.2011 (D. Badano) 5 L3. Sardinia, Sorso (Sassari), Platamona, coastal dune, VIII.2012 (D. Badano), 3 L3. Sicily, Gurne dell'Alcantara (Messina), VII.2010 (A. Corso), 5 L3. **Greece.** Corfu, Korission lake, coastal dune, V.2012 (D. Badano), 1 L3. Corfu, Agia Varvara V.2012 (D. Badano), 1 L3 laboratory-reared to adult. **Romania.** Dobruja, Agigea, VIII.2010 (C. Mancini), 1 L3. Dobruja, Badabag, VIII.2010 (C. Mancini), 1 L3. **Tunisia.** Gammarth, VII.2010 (local collector), 5 L3.

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**FIGURE 29.** *Myrmeleon bore* (Tjeder, 1941), 3<sup>rd</sup> instar larva (Germany: Mecklenburg Vorpommern, Graal Müritz). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



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**FIGURE 30.** *Myrmeleon inconspicuus* Rambur, 1842, 3<sup>rd</sup> instar larva (Italy: Veneto, Venezia, Punta Sabbioni). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 35 specimens): BL 8.08 mm; HL 1.70 mm (1.52–1.92), HW 1.48 mm (1.38–1.65), ML 1.67 mm (1.33–1.85), HW/HL 0.87, ML/HL 0.98. General colouring greyish ochre with a dark brown pattern, ventrally paler with dark brown markings; dorsal side of the head capsule with large dark markings on the clypeo-labrum, lateral sides of the head with dark markings, ventral side of the head pale with a pair of dark spots (Figs. 5E, 30b); mandibles pale brown; legs pale; setae of the body black. Head slightly longer than wide; mandibles as long as the head capsule (Fig. 30a); interdental mandibular setae: (~5)(2–3)(2–3)(1); dorsal side of the mandible covered by few short setae disposed toward the margins, ventral side with few isolated setae at the base. IX abdominal sternite with irregularly disposed digging setae on the ventral side, followed by a row composed by at least 5 equal-sized digging setae, rastra each bearing 4 digging setae of which the external ones are the longest (Figs. 6E, 30c).

**Bio-ecology.** A relatively euryoecious species, *M. inconspicuus* is associated with sandy environments such as coastal dunes, sub-deserts, internal sand deposits and banks of watercourses, besides it also colonizes other microhabitat with presence of loose substratum such as dry open woods or grasslands. The larvae build their pits in exposed conditions, often in proximity of vegetation such as at the base of trees growing on back dunes. *M. inconspicuus* is often the most common pit-building antlion on coastal sand dunes, colonizing both open dunes than back dunes with a complex vegetation, despite in the southern coasts of the Mediterranean it is replaced by more termophilous species in exposed conditions.

**Distribution.** Widespread in the western Palaearctic region.

**Remarks.** The larva *M. inconspicuus* resembles other congeners with which it is often syntopic such as *M. bore* and especially the closely related *M. mariaemathildae*. This species is mainly recognizable thanks to pigmentation and disposition of digging setae on the IX abdominal sternite. According to Krivokhatsky (2011), the larva of the similar *M. immanis* Walker, 1853 is differentiated by the shape of markings on the clypeo-labrum.

### ***Myrmeleon mariaemathildae* Pantaleoni, Cesaroni & Nicoli Aldini, 2010**

(Figs. 5F, 6F, 31)

The larva of this antlion was concisely treated in the species description (Pantaleoni *et al.* 2010).

**Examined specimens. Italy.** Sardinia, Sorso (Sassari), Platamona, coastal dunes, VIII.2012 (D. Badano), 3 L3. Sardinia, Cabras (Oristano), Tharros, coastal dunes, III.2011 (D. Badano), 1 L3. **Tunisia.** Tabarka, VII.2006 (R. A. Pantaleoni), 5 L3. Gammarth, VII.2010 (local collector), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 10 specimens): BL 9.28 mm; HL 1.70 mm (1.60–1.81), HW 1.48 mm (1.42–1.57), ML 1.64 mm (1.54–1.80), HW/HL 0.87, ML/HL 0.96. General colouring pale ochre with dark markings, ventral side paler with dark spots; dorsal side of the head capsule with anterior dark markings, lateral sides of the head with small dark marks, ventral side of the head pale with a pair of median spots of variable intensity according to individual (sometimes absent) (Figs. 5F, 31b); mandibles pale brown; legs pale; setae of the body black. Head slightly longer than wide; mandibles as long as the head capsule (Fig. 31a); interdental mandibular setae: (4–5)(1–2)(1–2)(1); dorsal side of the mandible with a sparse covering of short setae on the margins, ventral side of the mandible with few isolated setae at the base. IX abdominal sternite equipped with irregularly disposed ventral digging setae and a row composed by large bristles irregularly interspersed with small setae; rastra not prominent, each bearing 4 digging setae of which the external ones are the longest (Figs. 6F, 31c).

**Bio-ecology.** The larvae of this recently described species usually colonize open coastal sand dunes with a vegetation covering limited to pioneer psammophilous plants. The pits are normally built in exposed conditions, often at the base of tufts of herbs.

**Distribution.** Exclusively reported from Sardinia and Tunisia.

**Remarks.** The larva of *M. mariaemathildae* is very similar to the closely related *M. inconspicuus* noticeably differing in the paler colouring of the body and in the IX abdominal sternite. The same characters permit to distinguish this species from other European congeners. In Sardinia, *M. mariaemathildae* shares similar ecological requirements with *M. hyalinus* but the two species cohabit only in few sites with moderate anthropic disturbance.



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**FIGURE 31.** *Myrmeleon mariaemathildae* Pantaleoni, Cesaroni & Nicoli Aldini, 2010, 3<sup>rd</sup> instar larva (Italy: Sardinia, Sassari, Platamona). Dorsal (above), ventral (middle) and lateral (below) view; a–c: diagnostic characters, see species description.

### ***Myrmeleon hyalinus* Olivier, 1811**

(Figs. 5G, 6G, 32)

The larva of this antlion was described for the first time by Auber (1956b) and later by Willmann (1977).

**Measured specimens. Italy.** Sardinia, Alghero (Sassari), under rock overhang, VIII.2010 (D. Badano & R. A. Pantaleoni), 6 L3; same locality, IX.2010 (D. Badano), 1 L3. Sardinia, Cagliari (Cagliari), Molentargius, sand deposits, XI.2011 (D. Badano), 3 L3. Sardinia, Chia (Cagliari), coastal dune, XI.2011 (D. Badano), 5 L3 and 1 L3 laboratory-reared to adult. Sicily, Mazara del Vallo (Trapani), Gorgi Tondi, IX.2010 (M. Romano), 5 L3; same locality, IX.2011, 7 L3. Sicily, Mazara del Vallo (Trapani), Capo Feto, IX.2010 (R. A. Pantaleoni), 2 L3. Sicily, Linosa Island (Agrigento), IX.2010 (A. Corso), 3 L3. **Greece.** Rhodes, Tsambika, coastal dunes, XI.2010 (R. A. Pantaleoni), 1 L3. **Morocco.** Tissint, III.2011 (A. Corso), 4 L3. **Tunisia.** Ras Remel, V.2010 (A. Corso), 3 L3. **Egypt.** Sharm el Sheikh, IX.2010 (A. Corso), 1 L3. Feiran Oasis, IX.2010 (A. Corso), 1 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 40 specimens): BL 8.08 mm; HL 1.74 mm (1.44–2.00), HW 1.30 mm (1.06–1.49), ML 1.64 mm (1.38–1.91), HW/HL 0.75, ML/HL 0.94. General colouring pale ochre with dark markings, ventral side whitish with dark markings; head capsule pale with anterior dark markings, ventral side of the head completely pale except a distinctive pair of median elongated markings (slightly faded in some specimens) (Figs. 5G, 32c), lateral sides of the head pale; mandibles pale; legs pale; setae of the body black. Head noticeably longer than wide, rectangular in shape (Fig. 32b); mandibles almost as long as the head capsule (Fig. 32a); interdental mandibular setae: (7)(2–3)(2–3)(1); dorsal side of the mandible bearing few short setae, ventral side covered by sparse, short setae external to the maxilla and few setae disposed internally to the maxilla. IX abdominal sternite equipped with an anterior row of 4 digging setae and with two sessile rastra each bearing 4 digging setae of which the external pair is the longest (Figs. 6G, 32d).

**Bio-ecology.** *M. hyalinus* is a characteristic species of warm open sandy biotopes such as coastal dunes and deserts. In southern Europe, this species is common on sand beaches although it also colonizes internal sandy deposits. The larvae of *M. hyalinus* build the pits in exposed condition often at the base of tufts of psammophilous plants or bushes, avoiding retrodunal environments with a closer vegetation. Exceptionally this species may be found in different microhabitats such as arenaceous escarpments and overhangs.

**Distribution.** Widely distributed in the Palearctic region from the Canary Islands to Iran, across southern Europe and North Africa, reaching Ethiopia in the south.

**Remarks.** Besides body colouring, *M. hyalinus* is unmistakable among European Myrmeleontini due to the rectangular head shape. In Sardinia *M. hyalinus* rarely cohabits with *M. mariaemathildae*, despite they share similar habitat preferences.

### ***Myrmeleon fasciatus* (Navás, 1914)**

(Figs. 5H, 6H, 33)

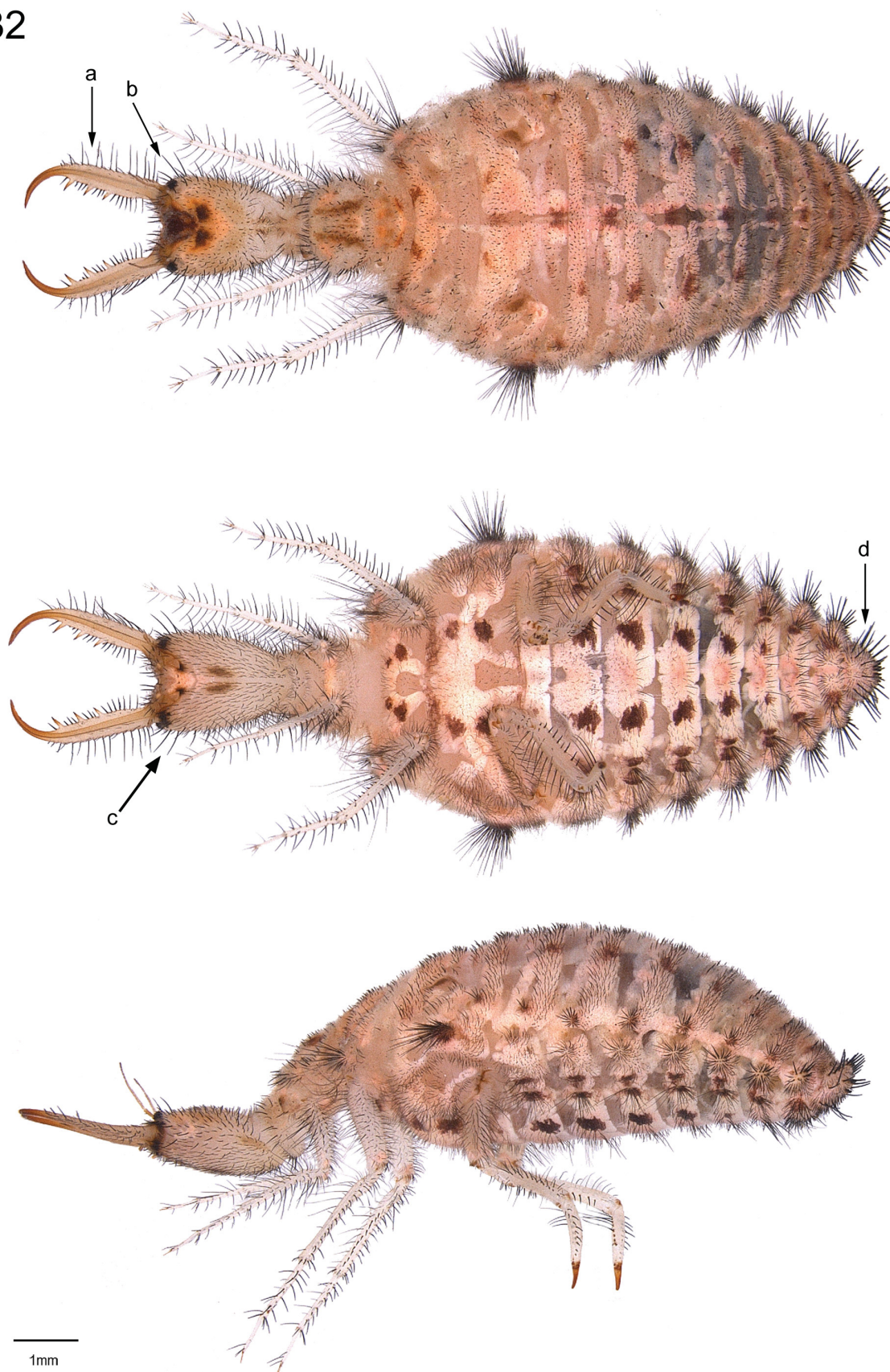
The larva of this species has been exclusively described by Willmann (1977).

**Examined specimens. Greece.** Rhodes, Kiotari, rock overhang, VII.2009 (D. Badano), 1 L3 and 3 L3 laboratory-reared to adults; same locality, XI.2010 (R. A. Pantaleoni), 19 L3. Rhodes, Kamiros, XI.2010, R. A. Pantaleoni, 8 L3; Rhodes, Kallitea, XI.2010, R. A. Pantaleoni, 3 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 31 specimens): BL 9.34 mm; HL 1.95 mm (1.70–2.20), HW 1.58 mm (1.37–1.77), ML 2.00 mm (1.76–2.10), HW/HL 0.81, ML/HL 1.03. General colouring pale ochre with few slightly faded markings, ventral side whitish without contrasting dark areas; head capsule pale with a slightly darker area on the clypeo-labrum, lateral and ventral sides of the head unmarked (Figs. 5H, 33c); mandibles pale; legs pale; setae of the body black. Head longer than wide; mandibles as long as the head capsule (Fig. 33a); interdental mandibular setae: (6)(2–3)(2–3)(1); dorsal side of the mandible covered by sparse short setae, ventral side of the mandible with a thick covering of short setae external to the maxilla reaching the apical tooth (Figs. 5H, 33b), few setae are disposed on ventral side of the mandible internally to the maxilla. IX abdominal sternite equipped with an anterior row of 4 digging setae and two rastra each bearing 4 setae of which the external pair is the longest (Figs. 6H, 33d).



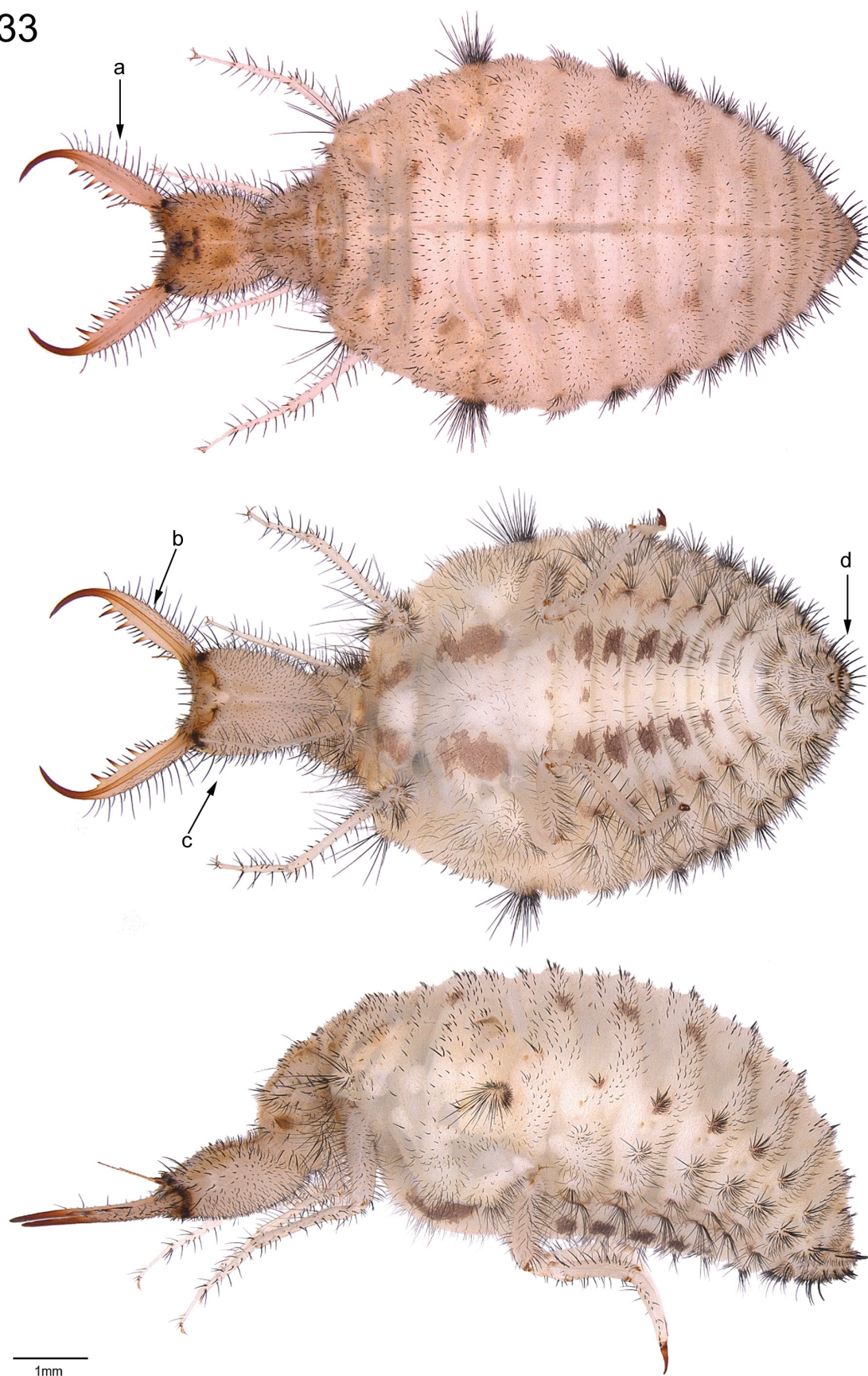
32



**FIGURE 32.** *Myrmeleon hyalinus* Olivier, 1811, 3<sup>rd</sup> instar larva (Italy: Lampedusa, Spiaggia dei Conigli). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



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**FIGURE 33.** *Myrmeleon fasciatus* (Navás, 1912), 3<sup>rd</sup> instar larva (Greece: Rhodos, Kiotari). Dorsal (above), ventral (middle) and lateral (below) view; a–d: diagnostic characters, see species description.



**Bio-ecology.** *M. fasciatus* inhabits very warm and xeric biotopes, including deserts. The larvae build their pits in sheltered conditions, such as under overhangs and cavities of sedimentary rocks, with the presence of very fine detritus or sand.

**Distribution.** *M. fasciatus* is widely distributed in North Africa and Middle East, while its presence in Europe is limited to the Greek island of Rhodos.

**Remarks.** Unmistakable among European Myrmeleontini thanks to the pale body colouring devoid of a contrasting dark pattern.

### ***Euroleon* Esben-Petersen, 1918**

**Diagnosis.** Anterior margin of the clypeo-labrum slightly concave; mandibles with 3 equidistant teeth of which the apical tooth is slightly longer than the others; 1 seta after the apical tooth; external margin of the mandible with long setae; pronotum covered by sparse short setae; meso- and metathorax with sessile setiferous processes; VIII abdominal sternite with odontoid processes, posterior margin covered by long and thin setae; IX abdominal sternite equipped with an anterior row of digging setae and two short rastra each bearing 4 digging setae.

**Examined species.** *E. nostras* (Geoffroy in Fourcroy, 1785).

**Comments.** *Euroleon* is a small genus, closely related to *Myrmeleon*, comprising only 6 described species of exclusively Palaearctic distribution. The larval stages of the widespread European *E. nostras* were described numerous times since the XVIII century (see text), while those of eastern species, *E. parvus* Hölzel, 1972, *E. polyspilus* (Gerstaecker, 1885) and *E. coreanus* Okamoto, 1926 were treated only recently (Krivokhatsky 1994, 2011).

The morphological characters of *Euroleon* fall in the range of variability shown by the numerous species included in the closely related genus *Myrmeleon*. The larvae of *Euroleon* are differentiated by the hair-like setae covering the posterior margin of the VIII abdominal sternite, while at least in the European species of *Myrmeleon* the VIII abdominal sternite is equipped with short or spiniform setae.

### ***Euroleon nostras* (Geoffroy in Fourcroy, 1785)**

(Figs. 1, 5I, 6I, 34)

The pit-building behaviour of this species attracted the attention of early naturalists such as Réaumur (1742) and Rösel von Rosenhof (1755) who treated its life history. Nevertheless the first scientific description was realized only a century later by Brauer (1857) actually naming this species *Myrmeleon formicarium* (see also under *M. formicarius*). Probably due its abundance in Europe, this antlion was extensively redescribed and it is probably one of the better known member of the family (Hagen 1873; Redtenbacher 1883, 1884; Eglin 1939, 1940; Friheden 1973; Steffan 1975; Gepp & Hölzel 1989; Gepp 2010; Krivokhatsky 1994, 2011). The account of Principi (1943) is particularly noteworthy for its accuracy and level of detail.

**Examined specimens.** **France.** Gard, Beauvoisin, relict sand dunes, VIII.2011 (D. Badano), 4 L3. **Germany.** Saxony, Dresden, VIII.2010 (C. Kehlmaier), 4 L3. **Italy.** Val d'Aosta, Aymavilles (Aosta), Pont d'Ael, rock overhang, VIII.2012 (D. Badano), 2 L3. Lombardy, Zelo Buon Persico (Lodi), VII.2010 (D. Scaccini), 7 L3; same locality, X.2011, 1 L3. Liguria, Mt. Toraggio (Imperia), rock overhang, VII.2010 (D. Badano), 2 L3. Lazio, Roma (Roma), Prati di Cervara, VI.2010 (M. Gigli), 1 L3. Lazio, Roma (Roma), Mt. Mario, IX.2010 (A. Alfonsi & C. Cesaroni), 1 L3. **Greece.** Corfu, Nissaki, V.2012 (D. Badano), 1 L3. **Turkey.** Cappadocia, 2 km from Göreme, V.2010 (A. Letardi), 1 L3. **Georgia.** Tbilisi (surroundings), VIII.2011 (C. Deiaco), 25 L3.

**Description of 3<sup>rd</sup> instar larva.** Size (based on 46 specimens): BL 9.32 mm; HL 2.24 mm (1.91–2.55), HW 1.84 mm (1.57–2.13), ML 2.26 mm (2.00–2.60), HW/HL 0.82, ML/HL 1.01. General colouring reddish brown with dark markings, ventral side pale with large dark markings; dorsal side of the head capsule with an anterior pair of spots and a V-shaped brown marking, ventral side of the head pale mottled with brown, with a median pair of elongated markings and a pair of spots (Figs. 5I, 34c); mandibles pale brown, lateral sides of the head with dark markings. Head longer than wide; mandibles as long as the head capsule (Fig. 34a); interdental mandibular setae (~4)(2)(2)(1); dorsal side of the mandible covered by short setae both on the external and internal margin, ventral side with a thick covering of short setae external to the maxilla, reaching the basal tooth (Figs. 5I, 34b) and with

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**FIGURE 34.** *Euroleon nostras* (Geoffroy in Fourcroy, 1785), 3<sup>rd</sup> instar larva (Italy: Latium, Roma, Prataglia di Cervara). Dorsal (above), ventral (middle) and lateral (below) view; a–e: diagnostic characters, see species description.



sparse setae disposed internal to the maxilla (Fig. 34a). Posterior margin of VIII sternite covered by hair-like setae (Fig. 6I; 34d); IX abdominal sternite with an anterior row of 4 digging setae and with two short rastra each bearing each 4 digging setae (Figs. 6I, 34e).

**Bio-ecology.** *E. nostras* is an euryoecious species reported from a vast array of biotopes from the sea-level to mountains, despite avoiding very xeric environments. The pits are built in sheltered conditions wherever a suitable loose substratum is present, thus the larvae are normally found under rock overhangs, near escarpments, at the entrance of caves and at the base of trees. Generally *E. nostras* prefers woody environments and in open sites, such as river banks and dunes, it is found in protected conditions. The requirement for sheltered corners predisposes this antlion to live in proximity of artificial structures such as buildings, rock walls and bridges. Interestingly the larvae of *E. nostras* are often found in unreachable corners for themselves such as tree holes, probably representing oviposition sites of females

**Distribution.** Widespread in the western Palaearctic.

**Remarks.** The larvae of *E. nostras* are noticeably similar to the species of *M. formicarius*-group in the overall habitus and the disposition of digging setae on the IX abdominal sternite, however they are recognizable for the absence of spots on the metathoracic pair of legs. Moreover the reddish colour of the body permits an easy identification of this antlion.

## Discussion

Larval morphology appears to be an important tool to improve the systematics of the family Myrmeleontidae. The western European fauna is relatively small, however the comparison between genera and tribes performed during the present study allows to draw some relevant preliminary conclusions. The first instar larva of *Palpares*, the only European member of Palparini, is equipped with rastra not dissimilar from the other member of the family, while the conspicuous fossoria appear only in later instars thus probably representing an adaptation to burrowing backward in a large-sized larva. Overall the morphological features of the larvae of Palparini do not warrant their status as separated subfamily as already underlined by Mansell (2004). The larva of *Dendroleon*, the only examined member of Dendroleontini, is characterized by a peculiar morphology that is a clear adaptation to a life as an ambush predator in small, dark cave-like habitats; further studies on the larvae of this complex tribe are necessary. The larvae of genera of Nemoleontini are noticeably uniform and conservative in morphology, often differing only in minor morphological features such as chaetotaxy, confirming the validity of this taxon. The tribes Myrmeleontini, Acanthaclisini, Myrmecaelurini and Nesoleontini share a combination of common characters such as: sessile ocular tubercles, labial palpi shorter than mandible width, mesothoracic spiracles not raised, thorax with sessile setiferous processes, meso- and metathoracic pair of legs with a fringe of setae, suggesting a close relationship as already noted on adult characters for some of these tribes (Markl 1954). Myrmecaelurini and Nesoleontini appear to be extremely close as their larvae are noticeably similar without prominent diagnostic features. Interestingly some characters shared between Myrmeleontini, Myrmecaelurini and Nesoleontini are however due to convergence in the pit-building behaviour, such as the long setae on the external margin of the mandible. At the same time, the conspicuous differences in the digging structures of the IX sternites between Myrmeleontini and Myrmecaelurini/Nesoleontini clearly suggest that the pit-building behaviour evolved independently at least two times in this group. A deep and comprehensive study of the larvae of genera of this group is necessary to solve the relationship of this lineage.

The European fauna approximately comprises 50 species of Myrmeleontidae, excluding Macaronesian islands and few Centro-Asiatic species reaching the ill defined border between Europe and Asia (H. Aspöck *et al.* 2001). Larval stages are known for slightly less than a half of them and often their descriptions are inadequate or lacking in-depth comparisons. The present research includes 28 species, of which 9 are accurately described for the first time, thus covering most species of western and central Europe. Nevertheless the state of knowledge of the larvae of European Myrmeleontidae is far from be considered exhaustive, as the larvae and ecology of many southern European species are still unknown (mostly rare non pit-building antlions). Finally, a serious obstacle is represented by the still confused taxonomic conditions of the most speciose genera.

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